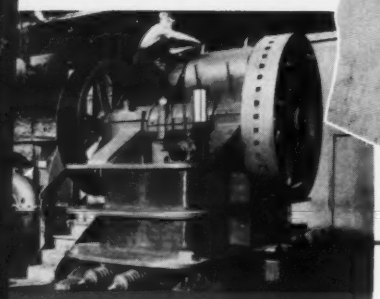
APRIL, 1948
Vol. 4----No. 2

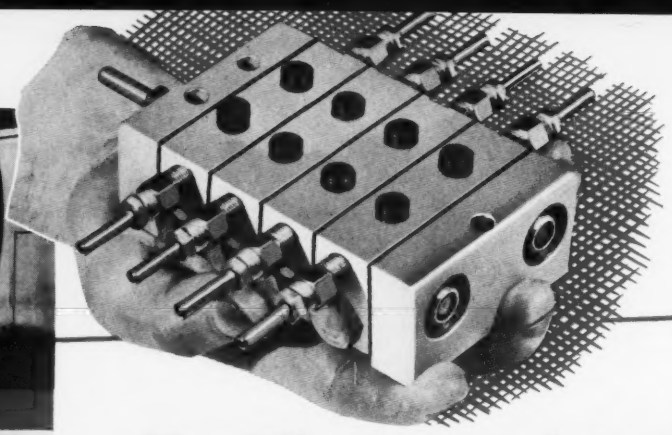
Lubrication ENGINEERING

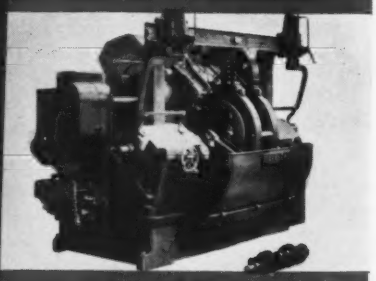
CONVENTION ISSUE

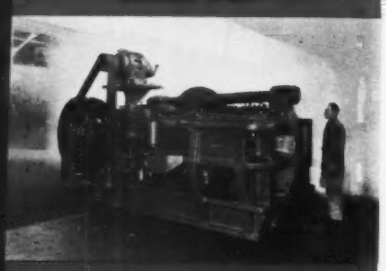
ANNUAL A.S.L.E. CONVENTION AND EXHIBIT
APRIL 19, 20, 21, 1948
HOTEL STATLER, BUFFALO, N. Y.

JOURNAL OF THE AMERICAN SOCIETY OF LUBRICATION ENGINEERS

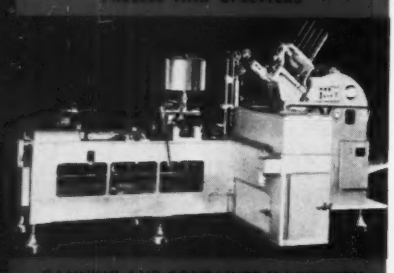




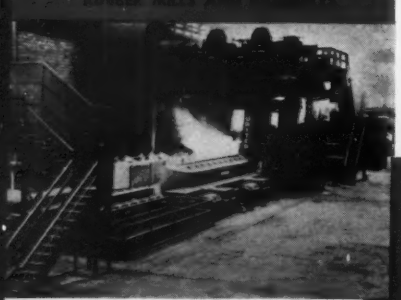




PRESSES AND UPSETTERS



CANNING AND CONTAINER MACHINERY



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Men Who Know Lubricating Systems *Specify Trabon*

Check these Operating Features and you'll realize why plant engineers and master mechanics prefer Trabon

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- **Progressive Operation**—Feeder sections operate progressively, one after the other. Each piston discharges its full measured amount of lubricant before the main hydraulic flow from the pump can reach and operate the next piston. *This makes it impossible to skip or under-lubricate a bearing.*
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- **Rugged, Steel, Sealed Feeders**—Vibration-proof, heavy steel feeders are completely sealed and have no exposed moving parts. The sealed Trabon System can be buried underneath dirt, grime, coal dust or even concealed inside the machinery. For the single indicator at the pump tells the story!
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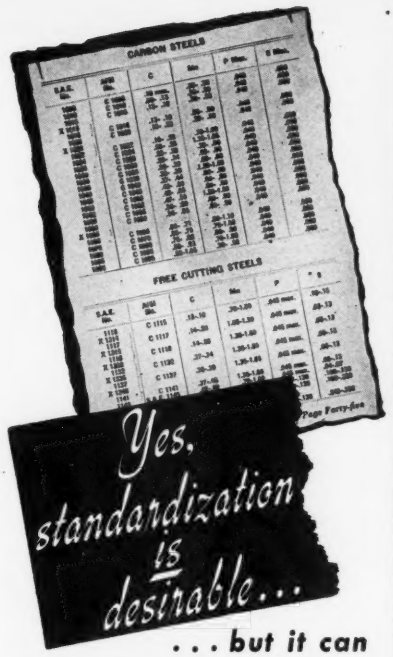

. . . but it can also cause trouble when it comes to Cutting Fluids

While it is obvious that the number of different types of cutting fluids used in any plant should be kept to a minimum, over-standardization can be very costly. There is no universal "one-shot" cutting fluid. The many variables involved in the wide variety of machining operations encountered in most shops make it difficult for any one individual to make the most intelligent selection and application of cutting fluids. The D. A. Stuart Oil representative has behind him the resources of 82 years' company experience, a finely equipped laboratory and a sound list of products. He will not be unsupported when he calls to help you. His recommendations will not call for more different fluids than are essential to maximum performance, but on the contrary, may result in a decrease in the number of oils used in your shop.

Literally thousands of authenticated case studies prove Stuart products, coupled with Stuart service, almost always result in greater production, better finishes and longer tool life. Don't overlook the opportunities afforded by proper cutting fluids properly applied. Write today and ask for D. A. Stuart's booklet, "Cutting Fluids for Better Machining".

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Lubrication ENGINEERING

VOL. 4 **APRIL, 1948** **NO. 2**

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LUBRICATION ENGINEERING
Official Publication of the American Society of Lubrication Engineers
343 SOUTH DEARBORN ST., CHICAGO 4, ILL.

BURGESS H. JENNINGS, Editor
Northwestern Technological Institute, Evanston, Ill.

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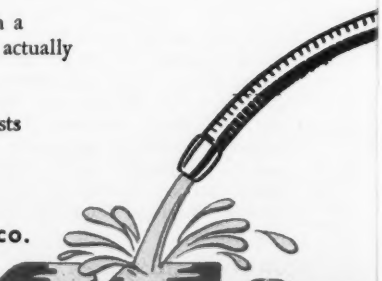

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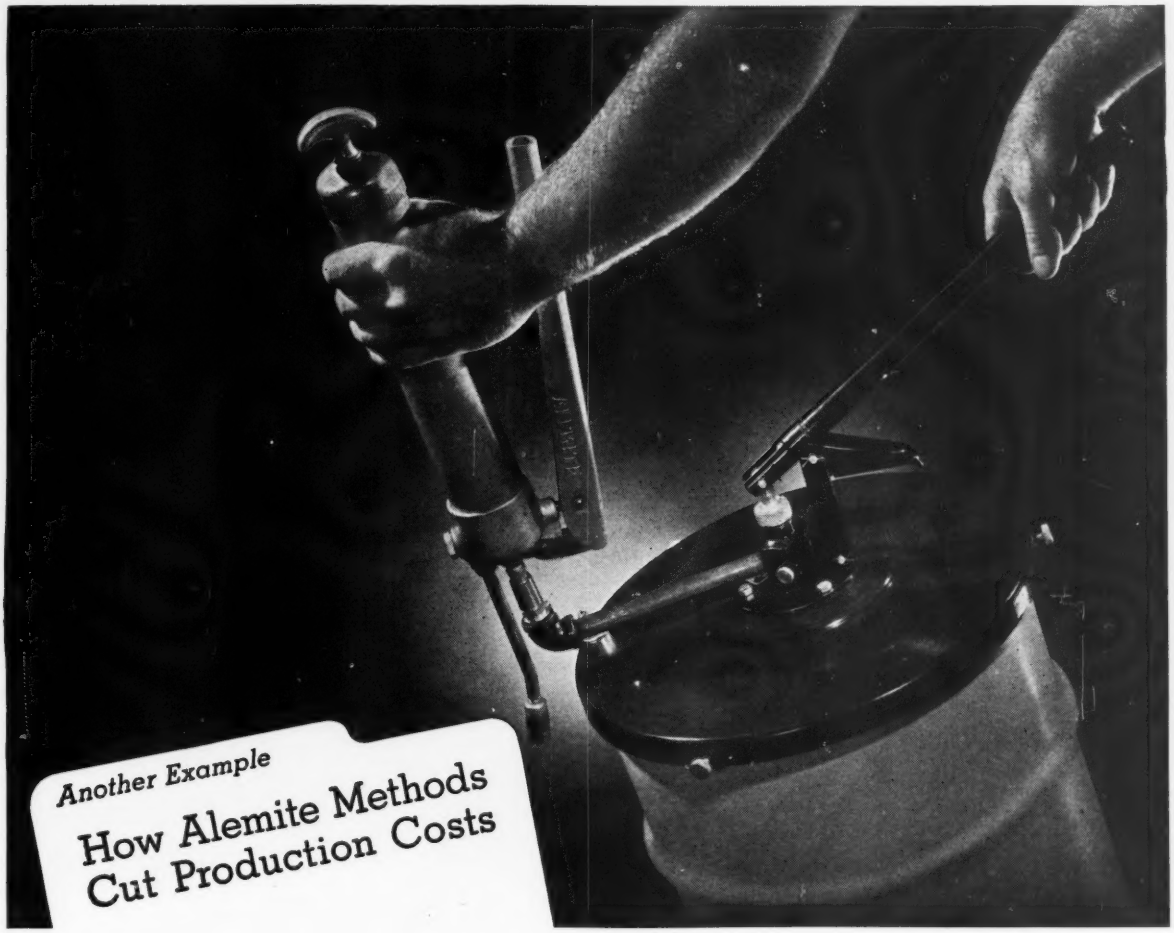

Saves 3¾ Hours Per 100 lbs. of Grease!

Increases Productive Time of Machines by Fast, Clean, Mechanized Handling and Application of Lubricants

Your Lubrication Methods May Be More Antiquated Than You Suspect

A simple thing like using the hand and paddle method to fill a grease gun boosts maintenance costs . . . and that means lower productive capacity per dollar per machine. The Alemite Representative is a *specialist* in modern methods of handling and applying lubricants. A five minute conference with him may open your eyes to new cost-cutting ideas. So, contact your Alemite jobber, or write Alemite, 1847 Diversey Parkway, Chicago 14, Illinois.

You use hand guns in your plant. Then listen to this. Alemite's new method of loading a hand gun can save up to 3¾ manhours for every 100 lbs. of grease you use! Three and three-quarters hours you can apply to other much needed preventive maintenance work.

A minor operation yes, but it's such savings that help to augment your drive to cut production costs. In addition, this Alemite Method saves grease and eliminates mess . . . keeps dirt and moisture out of lubricants.

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See you at Buffalo...

AT the third annual convention of the American Society of Lubricating Engineers, some of us will be there to greet you personally. Others must stay out on the firing line to help solve plant lubrication problems. So whether you're among those fortunate enough to attend the Buffalo gathering, or if you must stay on the job, please bear in mind that the full plant, technical and laboratory facilities of our organization are at your service—for better lubrication.

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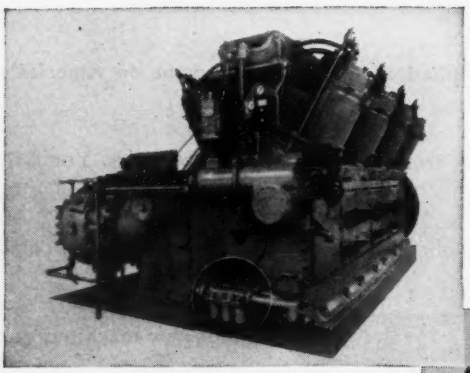
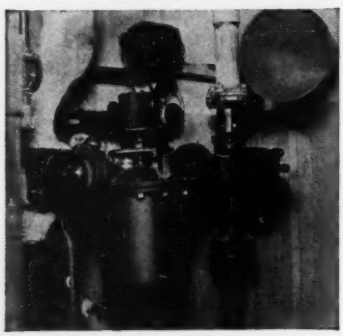
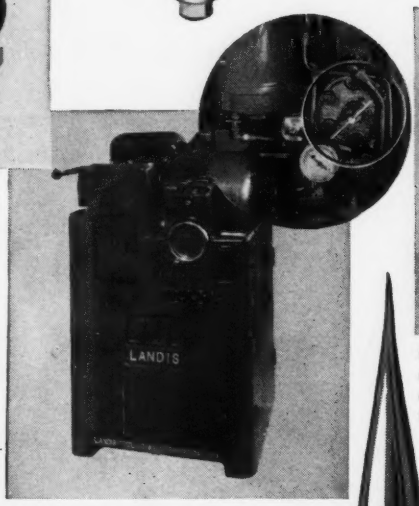


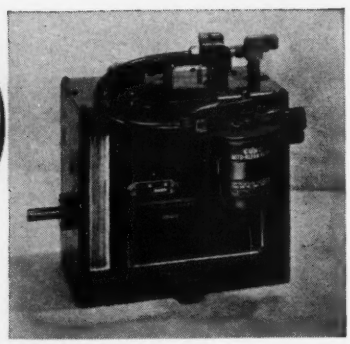
CONTINUOUS CLEANING is why this Diesel manufacturer selected Cuno Auto-Klean Filters as standard equipment. Externally-mounted all-metal filters are cleaned—without stopping flow—by periodic turning of handle.



AUTOMATIC FILTER CLEANING by motor drive is used in this installation where soap is filtered at 300 lb per minute by Cuno Auto-Klean, an application where pressure loss must be minimum.



COMPACTNESS of Cuno Auto-Klean appealed to designers of this high-speed grinder. Built-in cartridge handles full flow of hydraulic system in same space as usual partial-flow type.



POSITIVE REMOVAL not only of metal chips, fine dust, and powder but also of water, from lubricating oil, protects printing presses, special machinery, etc., serviced by this Automatic Lubricator.

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Model 78 Visi-Flusher

Model 2800 Air Operated Grease Gun

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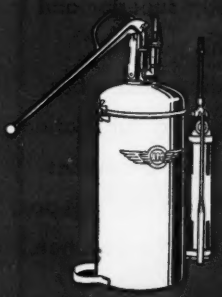
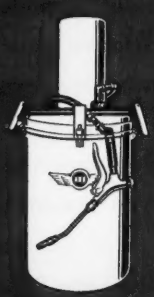


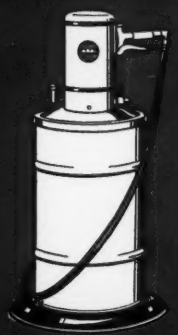
Model 2647 Heavy Duty Grease Gun with Filler



Model 2160 Air Powered Lubricator

Model 2130 Bucket Type Lubricator

Model 2691 Transfer Pump



Portable Model 51-S Drum Cover Type

Model 2200 Heavy Duty Drum Pump

Grease Fittings

In today's heavy production, lubrication is tremendously important. Aro's expertly engineered complete line of lubricating equipment has been designed to increase efficiency with less maintenance time and expense. A few of the items in the Aro line are shown here.

Send for details of Aro's complete line

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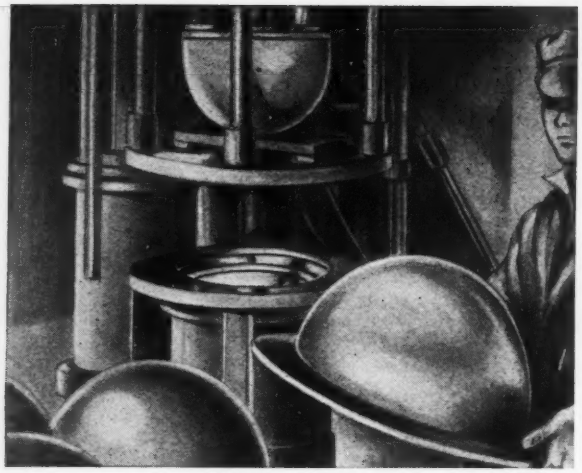
ARO

The Aro Equipment Corporation, Bryan, Ohio

High Temperature Lubrication... 400° F. and UP!



A fabricator of hot-drawn magnesium parts says, "At temperatures of 550°F. no oil retains its lubricating properties. Even grease is unsatisfactory. **"dag"** colloidal graphite is vastly superior and ir our plant is exclusively used for this purpose."

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We are interested in:

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2. Double Monel wire screen stops all solids.
3. Quiet Zone, below baffle plate, traps muck and moisture.

IF YOU'RE FISHING AROUND FOR A WAY TO LOWER OPERATING COSTS...

dollar for dollar

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will pay highest return on the money you invest

Your company is certain to make some important investments in equipment and services designed to reduce operating costs.

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For you, we have facts—actual records and data compiled by well known and respected manufacturers which prove our unqualified statement: "Dollar for dollar, oil purification pays the highest return on the money your company invests."

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☐ Machine Tool Soluble Oil Coolant (Ford Motor Company, Detroit, Mich. Motor Building Plant—precision motor parts.)

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for_____ operations. (fill in)

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Subsidiary of **HOUDAILLE-HERSHEY CORPORATION**

A BIJUR LUBRICATOR FOR EVERY MACHINE TOOL

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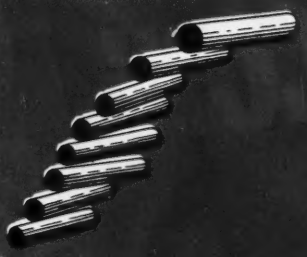
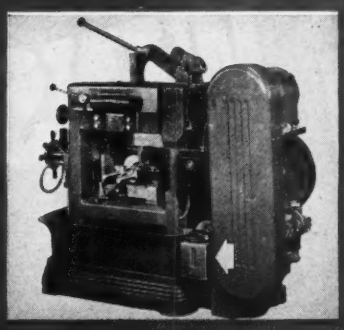
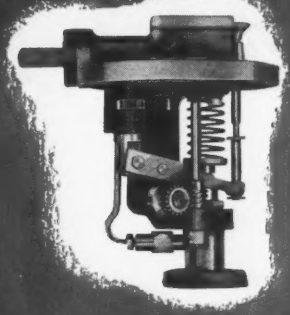


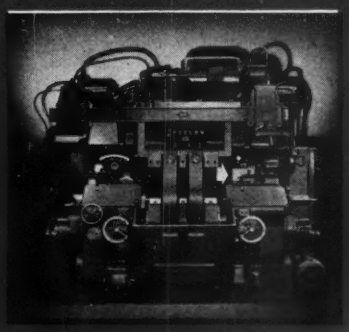


Peerless Machine-cut Saw. All 22 bearings and slides are regularly oiled by the cyclic lubricator.

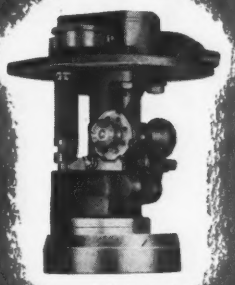


Cyclic lubricator unit discharges 60 drops of oil at 50 pounds pressure every 4 minutes.

TO CRANKSHAFTS



Le Blond 2 LB Line Bearing Crankshaft Lathe. Approximately 50 heavy-duty bearings and ways are constantly oiled by the high-pressure lubricator.



High-pressure lubricator unit discharges 630 drops of oil at 100 pounds pressure every 6½ minutes.

From raw stock to finished product-whatever operation your machine performs, it will run better on Bijur-oiled bearings. Assuring automatic distribution of clean oil to all bearings *while the machine is running*, the Bijur system insures maximum production while it reduces bearing wear. Built into machine tools, printing presses and sheet metal machinery, this central oiling system effectively lengthens the productive life of the machine. It will pay to talk over your lubrication problems with a Bijur engineer.

Write for the Bijur news bulletin. It shows how the system is applied.

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MEANS EVERYTHING IN MODERN FILTRATION

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WINSLOW FILTERS
Winslow Engineering Company

4069 Hollis Street • Oakland 8, California
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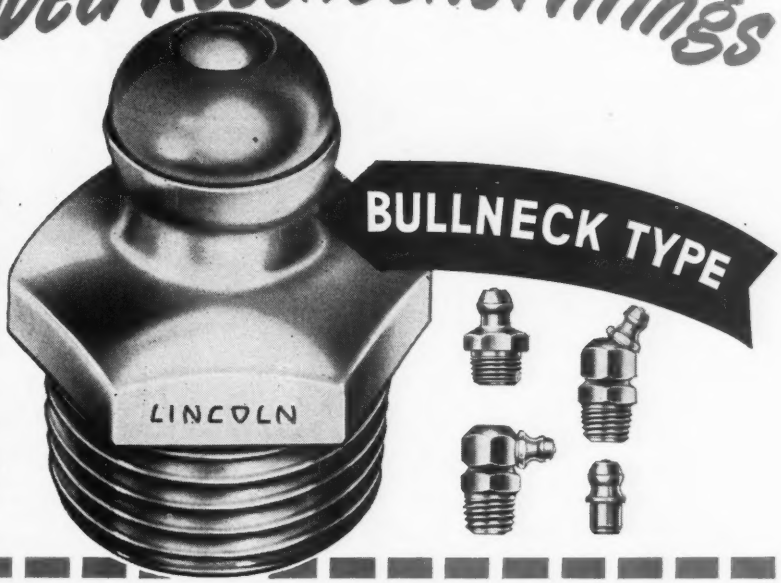
New Improved KLEENSEAL Fittings

- KEEP DIRT OUT OF BEARINGS...
- REQUIRE LESS PRESSURE
- PROVIDE MORE LUBRICANT VOLUME
- SECURELY CONTACTED BY ALL COMMERCIAL HYDRAULIC COUPLERS



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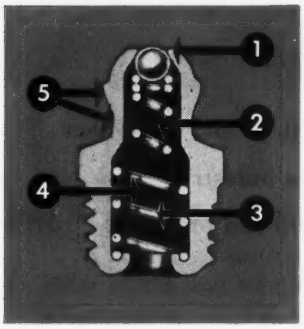

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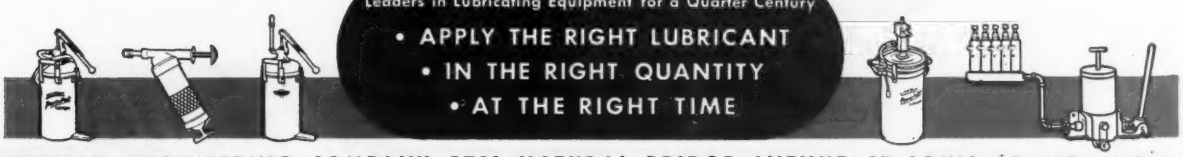

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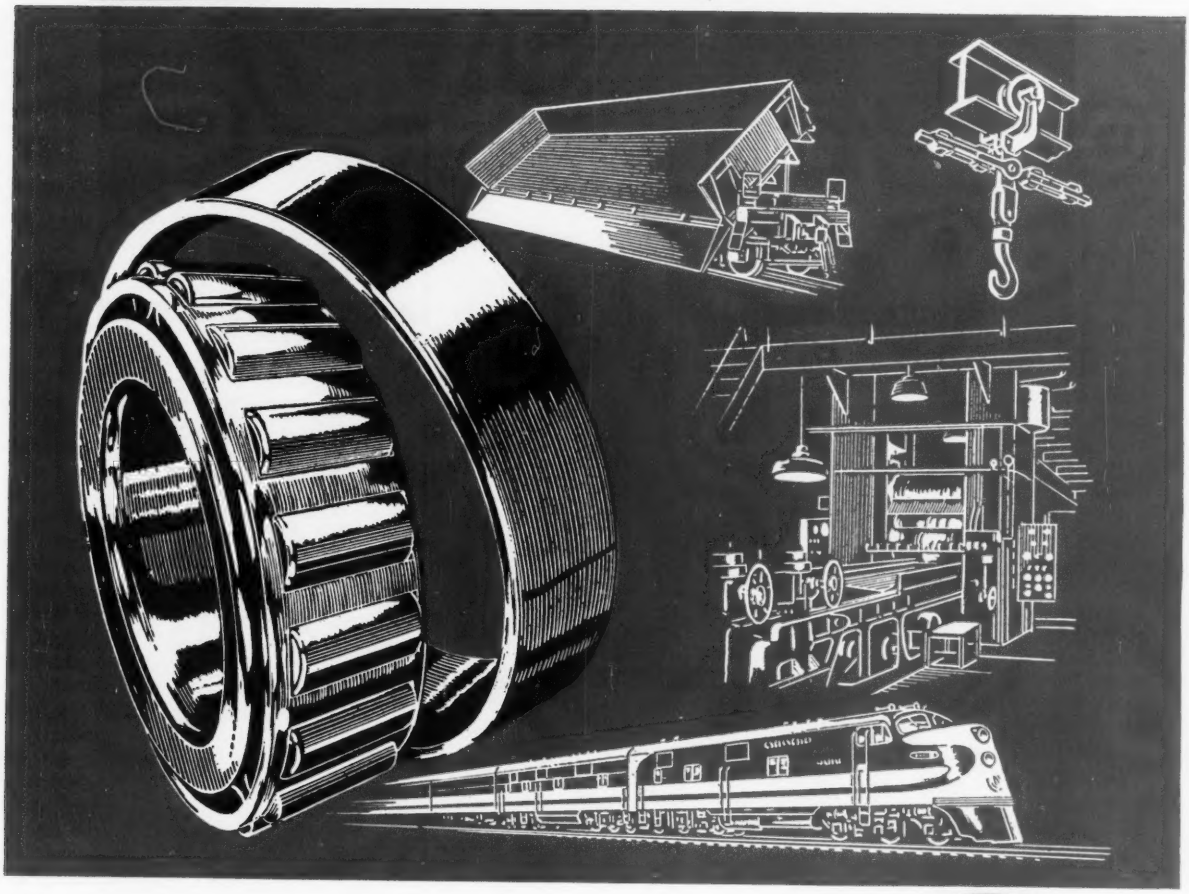

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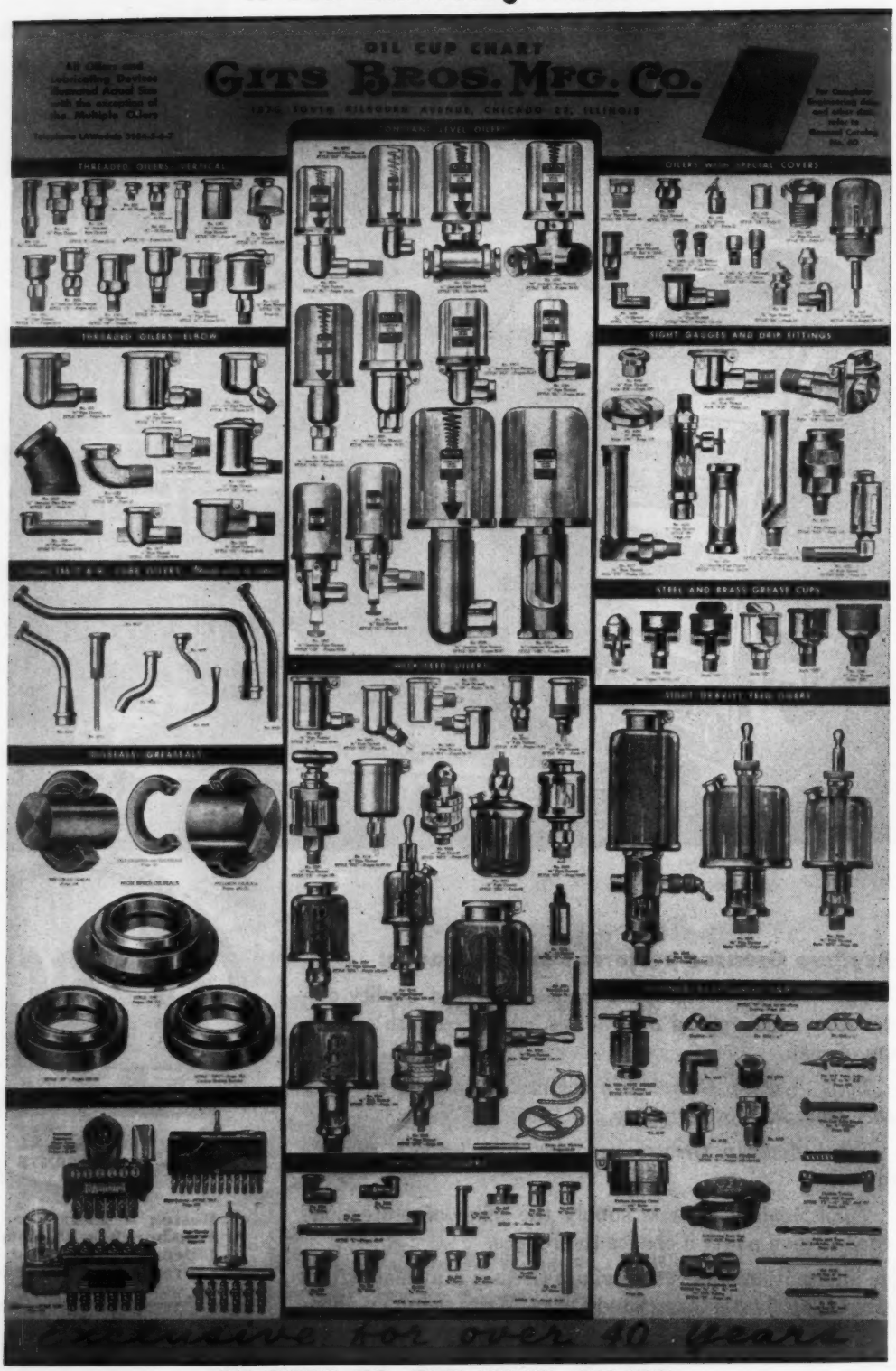
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THE EDITOR'S PAGE

EDITORIAL

WITH the passing of time, economic changes and technological advances can make ideas significant which previously were largely wishful thinking or imagination. In this realm we might classify the *Heat Pump* which is not new, as Lord Kelvin discussed the idea as far back as 1852, but only in the last few years has the idea received a full measure of active consideration.

In essence, the heat pump is a refrigeration machine which has as its objective not the production of "refrigeration" but the production of "heat." The evaporator of the heat pump absorbs heat at a low level of temperature from the atmosphere, running water, or from the ground and then, with the help of the work energy supplied to the compressor, converts this low-temperature heat to a high enough temperature level to make it suitable for heating homes or for industrial processes.

Although the heat obtained from the atmosphere or the ground may be considered to cost nothing, nevertheless it takes some electrical (or mechanical) energy to raise the temperature level of this heat and make it useful for warming a building. The amount of electrical energy required increases with the temperature lift through which the heat must be elevated. For example, with thermal energy outside at 50°F, it is not difficult for the refrigerator to raise its discharge (condensation) heat to 100°F for warming a dwelling. If, on the other hand, it is 30°F outside, the temperature lift is increased from 50 to 70 degrees, and when it is zero outside, the lift will change from 50 to 100 degrees. The greater the temperature lift, the greater the electrical energy required, and it was formerly thought that heat pumps were feasible only in very mild climates where both the heating load and the temperature lift were small. In terms of heating with a 50°F evaporator outside, it is easily possible to deliver 4 kilowatt hours of useful heating at 100°F at the expense of but one kilowatt hour of electrical energy brought from the power company. Thus 4x3413=13,652 Btu are converted into useful heating for the cost of one kilowatt hour of electricity, which ranges from 4 down to perhaps 1 cent. Even at 1 cent a kilowatt hour, this appears to be a high price to pay for heating, and it was, not many years ago.

However, this country had a coal strike which was followed by an appreciable increase in the price of coal. This, in turn, increased the demand for fuel oil and, along with the distribution problem, the price of fuel oil rose to exorbitant levels. Domestic fuel oil moved from 7 to 15 cents a gallon and, of the 144,000 Btu per gallon, perhaps 110,000 Btu are realized in the home as useful heat. With prices of this sort the heat pump is no longer an inventor's dream but an economic reality because the power cost is less than the cost of typical fuel oil. Whether fuel oil will stay at these levels, and whether power with rising costs of coal can stay at the low levels which it has reached, remains to be seen, but the fact is that economic conditions have forced a reconsideration of our whole viewpoint in regard to this particular item.

In the northern sections of the country it is obvious that with winter temperatures dropping down to zero and below, the power requirements for a heat pump would rise excessively and set an undue burden upon a utility system whenever a spell of cold weather arrived. Thus a heat pump would be a very undesirable load and recent research has been directed toward methods of finding higher temperature sources of thermal energy in winter periods. The most obvious source of such energy is the earth itself which, within certain limitations, can serve this purpose. Below the frost line, which varies with different locations in the country (0 to 4 feet) the temperature in the ground is fairly constant throughout the whole year, not dropping below some 50°F even in the coldest weather. Consequently, if the evaporator coil for a refrigerator is buried in the ground, and excessive quanities of heat are not required from it, the adjacent ground, though thermal conduction, may be able to supply enough heat to keep the temperature of the coil from dropping below say 40°F throughout the heating season. This is particularly possible if the earth is moist, or if there are underground flowing circuits of water.

Many modifications for varying the type and area of the buried coils have been investigated, along with various methods laying the coils and improving heat transfer characteristics. Even the possibility of pumping water out of the ground, running it through an evaporator and pumping the colder water back into the ground at a different point have been considered and investigated. It seems doubtful that the heat pump is economically feasible as far north as Chicago, but it is certainly feasible in the middle and southern sections of the country, and who knows but what it may find usuage throughout the whole country.

If Lord Kelvin had found it necessary to rely on the heat pump to develop his fame as a great scientist, his patience might have been exhausted and he might have died a disappointed man in the hundred years wait before this one of his dreams was realized, but patience is one of the greatest assets which the research man possesses. It frequently happens, however, that those farthest from research have the greatest difficulty in realizing the need for patience. There is the story told of two partners who, by a lucky accident, had developed a chemical product which had been particularly lucrative to them. They decided that it would be stylish and maybe profitable if they employed a research chemist. About eleven o'clock on the first day of the chemist's employment one partner remarked to the other—"Should we go and see what the chemist has discovered?" to which the second partner replied—"No, it's a little too soon. Let's wait until after lunch."

B. H. JENNINGS, *Editor.*

*Oil Flows and Running Temperatures of Lightly Loaded Journal Bearings

By JOHN BOYD[1] AND B. P. ROBERTSON[2]

Abstract

The trend toward higher speeds for certain types of apparatus and the decrease in weight of the moving parts which usually accompanies such a change has resulted in the application of an increasingly large number of bearings which operate at relatively high speeds and comparatively light loads. Many of these applications use sleeve type bearings which are supplied with force feed lubrication.

Th combination of light loads and high speeds permits simplifying assumptions to be made in the calculation of oil flows and running temperatures.

The paper considers two common types of bearings and compares the predictions of theory based based on these assumptions with the results of experiment.

Mr. Boyd was born in Pittsburgh, and after graduating from high school entered Carnegie Institute of Technology where he received his degree in Mechanical Engineering in 1929. Later, worked at Carnegie in 1933 where he became Instructor in Mechanics and Strength of Metals. On leaving the Carnegie Institute, he went to South Philadelphia as a Turbine Engineer for the Westinghouse Corporation and has been with Westinghouse up to this date.

Mr. B. P. Robertson graduated from the University of Texas in 1942 with a BS degree in Mechanical Engineering, and has been employed by the Westinghouse Electric Corporation as a Research Engineer until January of 1947. Since that time he has been in the employ of the Humble Oil and Refining Company of Houston, Texas, as a Technical Service Engineer.

THE trend toward higher speeds in certain types of apparatus and the decrease in weight of the moving parts which usually accompanies such a change has resulted in the application of an increasingly large number of relatively high speed and comparatively lightly loaded bearings. In many cases, pressure lubricated journal bearings are employed.

In determining the oil flows, friction losses and running temperatures of such bearings, a fortunate circumstance exists which makes the calculation of these quantities much more simple than would ordinarily be the case. The simplification results from the fact that light loading and high speed produce only slight journal eccentricity. Thus, the journal and the bearing may, for many practical purposes, be considered as operating concentrically.

An important factor in determining the oil flow through a bearing is the type and distribution of the oil holes and oil grooves. Although many designs are used, only the following two common types will be considered here,

Type A—360° plain bearing with circumferential groove at midlength.

Type B—360° plain bearing with single oil supply hole on top at midlength.

Tests have been carried out on bearings of each type and the observed flows and temperatures compared with values calculated on the basis of concentric operation.

Test Apparatus

The test apparatus consisted of a shaft (2 in. dia. x 18 in. long) mounted in two accurately aligned bearings and driven through a light flexible shaft by a variable frequency drive.

The bearings (see Fig. 1) were made from an aluminum alloy and were in the form of inserts (2 in. I.D., 2¼ in. O.D., and 1⅞ in. long) which were pressed into housings set on 12 in. centers.

The Type A bearing had two lands each 0.593 in. long and a 0.250 in. wide x 0.020 deep circumferential groove. The edges of the groove were chamfered approximately 0.003 in. The inlet oil hole was ¼ in. dia. and opened directly into the groove. The diametral clearance was 5.3 mils.

The Type B bearing had a ¼-in. dia. oil inlet hole with approximately 0.003-in. chamfer. The diametral clearance was 5.1 mils.

The temperature of the inlet oil was measured by a thermocouple in the inlet oil line, near the bearing housing. The temperature of the bearing was measured by a thermocouple in the housing ¾ in. from the end of the bearing and ⅛ in. from outside diameter of the bearing insert. The outlet temperature was measured by a thermocouple arranged to contact the oil as it was thrown off by the bearing.

Oil flows were measured by determining the time required to pass a given volume of lubricant.

* Presented at 2nd Annual A.S.L.E. Convention, Pittsburgh, Pa., March 17-19, 1947.

[1] Westinghouse Research Laboratories, East Pittsburgh, Pa.

[2] Formerly with Westinghouse Research Laboratories, East Pittsburgh, Pa.

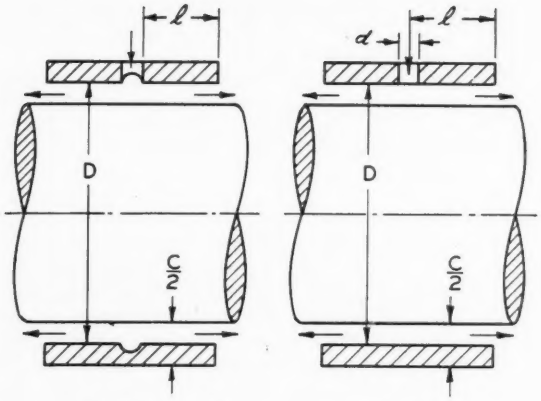

FIG. 1 TEST BEARINGS

Flow

In another paper* it was shown that the total oil flow, Q_A, through a Type A bearing operating without eccentricity could be expressed by the relation

$$Q_A = 1.175 \times 10^{-4} \frac{\triangle p \quad D C^3}{\mu l}$$

where Q_A = total flow — gpm
$\triangle p$ = inlet press. minus ambient press.— psi
D = bearing diameter — in.
C = diametral clearance — mils
μ = absolute viscosity — cp
l = axial length bearing land — in.

The above relation gives the flow with the journal running concentrically. Although the cross sectional area of the clearance space remains constant regardless of journal eccentricity, the flow increases as the journal departs from its central position because the greater flow through the thicker portion of the film offsets the decrease in flow through the thinner portion. Thus, at standstill when the eccentricity is greatest, the flow may be shown to be 2.5 times as large as for concentric conditions.

For the case of a bearing with a single inlet oil hole located on top, the total flow, Q_B, for a bearing operating concentrically was shown to be given by the following equation.

$$Q_B = 1.875 \times 10^{-3} \frac{\Delta p \, C^3}{\mu \left[\frac{l}{D} - 2\log_e \frac{d}{D} - 4 \sum_1^{\infty} \frac{1}{n(1+e^{2nl/D})}\right]}$$

where Q_B = total flow — gpm
$\triangle p$ = inlet press. minus ambient press.— psi
C = diametral clearance — mils
D = bearing dia.— in.
d = hole dia.— in.
μ = absolute viscosity — cp
n = an integer which has the values 1, 2, 3, 4 — (usually it is only necessary to include values of n up to 4).

Other conditions being equal, the flow through a Type B bearing is less than through a Type A bearing. The ratio Q_B/Q_A may be found by substituting numerical values in the above equations. For bearings of the test proportions

$$Q_B/Q_A = 0.276$$

The nature of the equations used for calculating the flow through a Type B bearing does not permit precise evaluation of the flow at zero rpm as was the case with the Type A bearing. Approximations, however, show that the Type B bearing is much more sensitive to eccentricity and that the flow at zero rpm is considerably greater than 2.5 times the flow for concentric conditions.

Fig. 2 shows the effect of oil pressure on oil flow for the two bearings at 12000 rpm. If it were possible to keep all variables except the inlet pressure constant, the calculated curves would be straight. However, as the flow increases the film temperature falls. The slight curvature of the calculated curve is due to corrections for changes in viscosity and clearance. The relative slope of the two sets of curves shows that the flow for the Type B bearing is approximately equal to the theoretical value of 0.276 times the flow for the Type A bearing.

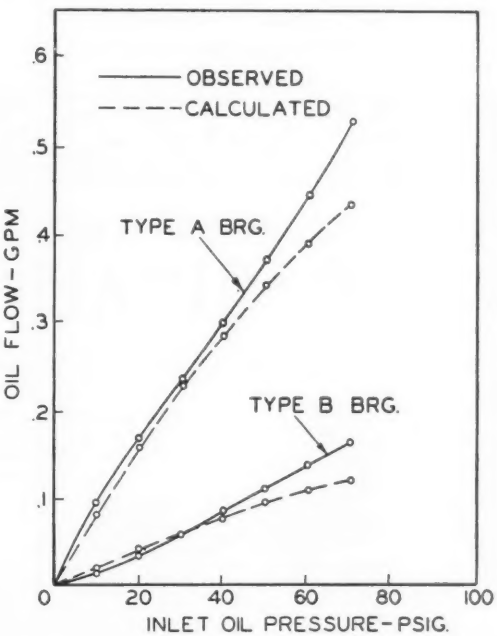

FIG. 2 EFFECT OF OIL PRESSURE ON OIL FLOW FOR TYPES A&B BEARINGS OPERATING AT 12000 RPM

Figs. 3 and 4 show the effect of speed on the oil flow for the two bearings. It will be noted that the agreement is better at the higher speeds and becomes less satisfactory as the speed decreases and the eccentricity

* "Oil Flows and Temperature Relations in Lightly Loaded Journal Bearings"—Boyd and Robertson—presented before the A.S.M.E., 1947.

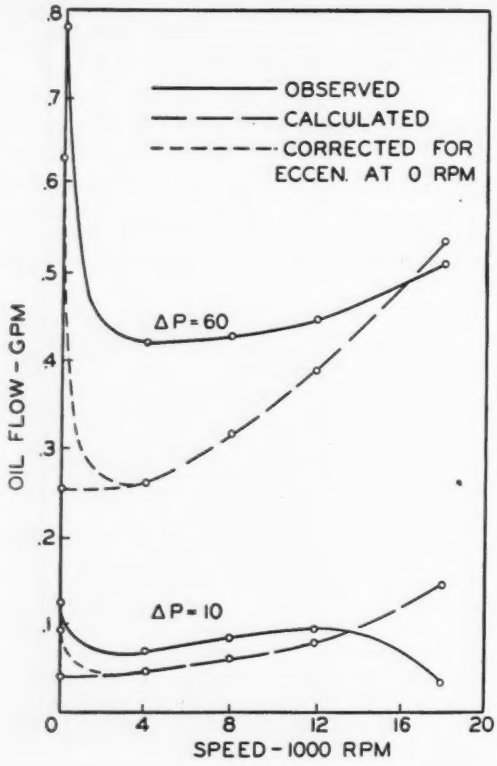

FIG. 3 EFFECT OF SPEED ON OIL FLOW FOR TYPE A BEARING

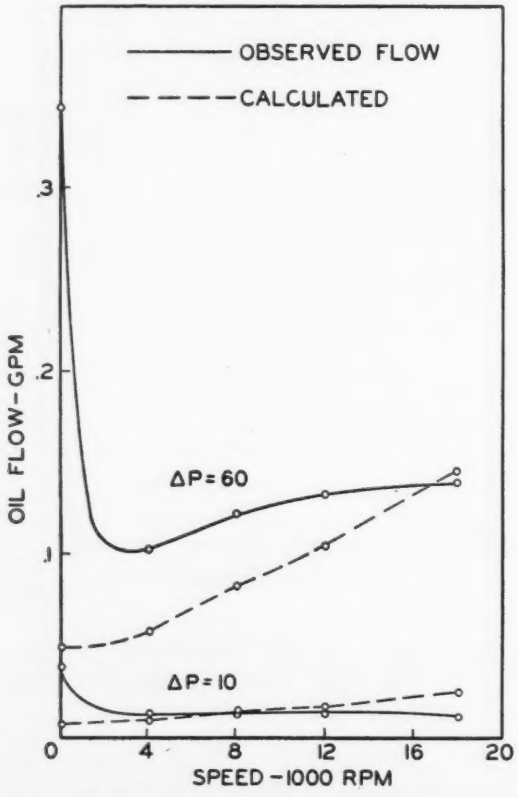

FIG. 4 EFFECT OF SPEED ON OIL FLOW FOR TYPE B BEARING

becomes larger. Correcting the curves for the Type A bearing by the 2.5 factor for zero rpm agrees fairly well with the results of experiment.

The drop in observed flow for the Type A bearing at the higher speeds and low oil pressures is due to the centrifugal effect of the oil in the circumferential groove which tends to oppose the inlet pressure.

Running Temperature

The running temperature is most easily determined by graphical means. This is done by solving the heat balance equation for the viscosity in terms of the temperature rise and plotting the resulting relation on viscosity temperature coordinates. The intersection of this curve with the viscosity temperature relation for the lubricant plotted on the same coordinates give the running temperature. (See Fig. 5.)

If the greater portion of the heat is carried away by the oil, as is frequently the case, and the heat loss through the journal and housing may be neglected, it was shown in the paper referred to above, that the viscosity in terms of the temperature rise may be expressed by,

$$\mu = \sqrt{B\overline{\Delta T}}$$

where $B = 3.64 \times 10^4 \dfrac{\Delta p \gamma c C^4}{l^2 N^2 D^2}$

and μ = viscosity — cp
C = diametral clearance — in.
D = bearing diameter — in.
l = axial length of bearing land — in.
N = journal speed — rpm
Δp = inlet oil press. minus ambient oil press. — psi.
C = specific heat of oil
γ = density of oil — lb./gal.
$\overline{\Delta T}$ = temperature rise of lubricant — F.

Fig. 5 shows the application of the above formula for determining the running temperature of a Type A bearing operating at 18000 rpm with an oil inlet temperature of 100°F. and an ambient temperature of 100°F. From the intersection of the calculated curves and the viscosity temperature curve of the lubricant used, the running temperature may be found. Thus the running temperature with AN06 is 180°F. and with medium turbine oil is 234°F.

The dotted lines show the effect of considering the heat carried away by the housing for the test setup.

A similar set of curves may be drawn for the Type B bearing but in this case it is necessary to put Q_B/Q_A into the equation for B in order to take care of the reduced flow through this type bearing. Thus

$$B = 3.64 \times 10^4 \frac{\Delta p \gamma c C^4}{l^2 N^2 D^2} \frac{Q_B}{Q_A}$$

Fig. 6 shows the calculated and observed running temperatures for the two bearings plotted as a function of the inlet oil pressure. As is to be expected the Type B bearing operates at a higher temperature because of the lower flow rate.

It will be noted that neglecting the housing loss did not introduce appreciable error for the conditions of the test setup.

(*Continued on pages* 61-62)

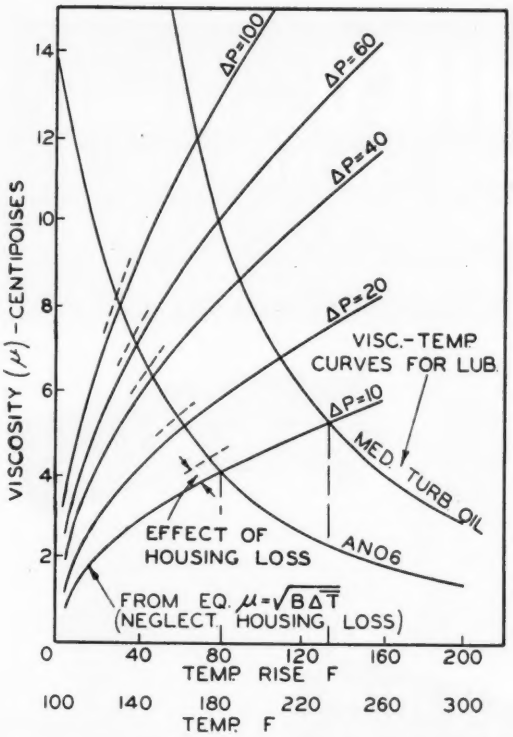

FIG. 5 SOLUTION OF EQUATIONS FOR RUNNING TEMP. 18000 RPM, AMBIENT TEMP=100 F INLET OIL TEMP=100 F

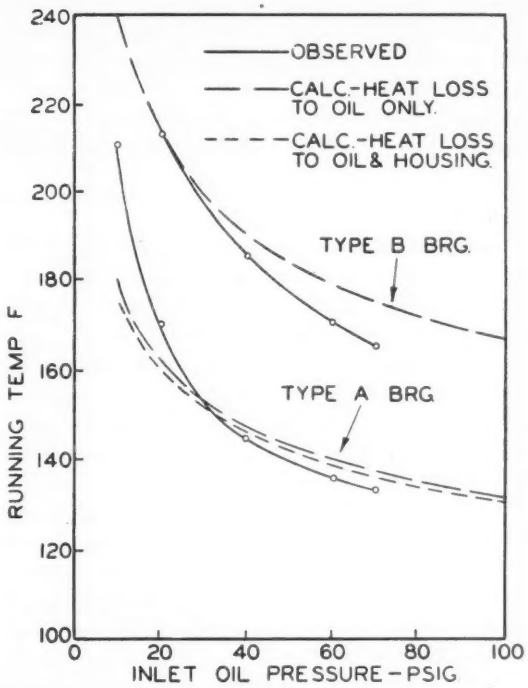

FIG. 6 EFFECT OF OIL PRESSURE ON RUNNING TEMP. FOR TYPES A&B BRGS. OPERATING AT 18000 RPM. INLET OIL TEMP. = 100 F-AMBIENT TEMP. = 100 F

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At the higher pressures, the calculated temperatures are on the safe side as may be expected since the eccentricity, and hence the flow, increase at higher pressure. The effect is more noticeable in the case of the Type B bearing in which the effect of eccentricity is greater.

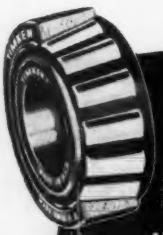
Conclusions

The test data indicate that the application of the above equations to relatively lightly loaded and comparatively high speed bearings may be considered satisfactory at least for a first approximation.

At low speeds the observed flows are considerably in excess of the calculated values because of journal eccentricity. Correcting the calculated flows for eccentricity at 0 rpm gives results that compare favorably with experiment.

Because of the centrifugal effect of the oil in the circumferential groove of a Type A bearing, the oil flow falls off at high speed and low inlet oil pressure.

Other conditions being equal, the flow through a Type B bearing of the test proportions is approximately 0.28 times the flow through a Type A bearing. Because of this, the Type B bearing will, in general, operate at a higher temperature.



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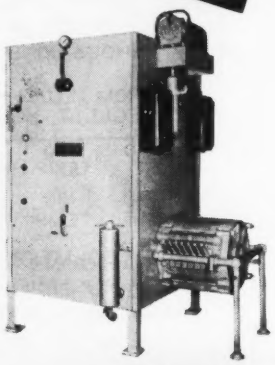

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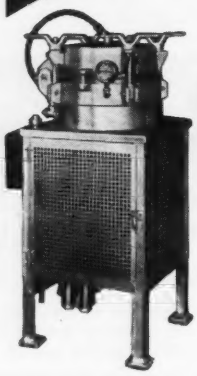

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By DR. JAMES W. RAMSAY

James W. Ramsay has been with the Socony-Vacuum Oil Company since 1930, with the exception of two years spent in graduate study at Cornell University. During that time, Dr. Ramsay has been engaged in development work on lubricants at the company's laboratories. He spent the past three years in the Technical Division of the Lubricating Department, and is now on the staff of the Socony-Vacuum Laboratories at 26 Broadway, New York City.

OVER a period of the last several years, the trend and design of new machinery, and the changes in operation of existing machinery have been toward more severe conditions with respect to lubricating oils. This has been demanded in order to attain a lower unit cost. In all types of machinery, this means a higher output for a given size. In internal combustion engines, these newly imposed conditions mean higher cylinder pressures and higher piston temperatures, with a resulting tendency toward increased wear and ring troubles. With units such as steam turbines, the use of fabricated parts in place of castings has increased the possibility of rusting.

Changes in design and changes in operating factors of a given type of machine are likely to render the available lubricant unsatisfactory. Changing the source of crude oils and improvements in refining procedures are usually unable to take care of all of these changing conditions. Hence, the addition of various chemicals or additives to carefully selected base mineral oils must be resorted to in order to solve many problems.

Types of Additives

Before entering a general discussion of additive oils, it is best to consider and define the various types of additives commonly used, such as anti-oxidants, detergents with anti-oxidants, rust inhibitors, lubricity agents and extreme-pressure compounds, pour-point depressants, and viscosity-index improvers.

Anti-Oxidants.

Anti-Oxidants may be subdivided into two general classes; true inhibitors and catalytic poisons. A true oxidation inhibitor may be defined as one which will prevent the oxidation of oil not only when oil and air are present but also when catalysts, such as metals, metal compounds, blowby gases, water, etc., are present. It seems most probable that they act by interrupting the "chain" reaction which takes place in the oxidation of oil.

Catalytic poisons, or "metal deactivators," function only in the presence of catalytic-type metals and are frequently in themselves oxidation promoters in the absence of these metals. The most common type of "metal deactivators" are those which neutralize the catalytic action of iron, copper and copper alloys. They have been extensively used to prevent the oxidation of fuels stored in copper tanks.

Detergents and Anti-Oxidants.

Detergents are generally paired with anti-oxidants and are rarely used alone. Detergent-type materials are used to maintain cleanliness in internal-combustion engines. In order to accomplish this, the additive combination must function both in the low-temperature crankcase zone as well as in the higher-temperature ring zone. With respect to the crankcase zone, nearly all investigators agree that the action of the additive is purely physical and acts to keep the oxidized material present in more or less permanent suspension. There are two distinct schools of thought regarding the action of the additive combination in the ring zone. One group contends that the action is comparable to that which takes place in the crankcase; namely one of physical suspension by adsorption of the compound by the contaminating particles. The other group believes that the additive modifies the oxidation process in the ring zone so as to form a type of carbon or oxidized material that is easily swept out with the exhaust, and therefore, not deposited in the ring grooves in the form of sludge or lacquer.

Rust Inhibitors

There are two classes of rust inhibitors; one type is that used in engine oils where the engine is operating in the presence of excessive moisture or salt mist, or where the effect of bromides in leaded fuel is a factor. An operation of this type calls for a very potent rust inhibitor which, by its chemical action, forms a surface coating on the metal parts to be protected. This surface coating prevents moisture from reaching the metal

surface, and thereby protects against rusting and corrosion.

The second type of rust inhibitor is used in various industrial oils recommended for circulation systems of the turbine type. It is much milder in its action and, therefore, would not be suitable to protect the interior of combustion engines. It is usually a highly polar-type material which, by its surface activity, forms an adsorbed film on the metal parts. This adsorbed film prevents the moisture from reaching the metal surface. Fatty acids, their esters and other derivatives are examples of such polar compounds.

Lubricity Additives and Extreme-Pressure Compounds

Lubricity additives are materials which, when added to lubricating oil, reduce the coefficient of friction in thin films. They may act through physical adsorption in much the same way as fatty acids and their derivatives do in the prevention of rust. Slightly more active agents may react with the metal surfaces due to the heat of friction. Such action tends more toward the film strength and extreme-pressure type of additive and the differentiation between the two is somewhat a matter of personal opinion.

Extreme-pressure compounds are usually thought of as organic materials containing sulphur or chlorine or both which, by virtue of active decomposition or chemical combination, form simple complex chlorine-sulphur salts on the metal surfaces. The exact compositions of the compounds formed are not known; they may or may not include a portion of the organic radical in the original compound. This film of metal salt is extremely helpful in minimizing the effects of metal-to-metal contact and thereby protecting against wear. In order to take care of all possible conditions involving both high and low speeds and high and low torques, it may be necessary to use a lubricity additive such as the fatty material along with the conventional sulphur and chlorine extreme-pressure compounds.

Pour-Point Depressants

When an oil containing dissolved wax is cooled below its saturation temperature, the wax crystallizes. With normal petroleum oils containing no additives, this wax separates in the form of interlacing crystals which prevent liquid flow. The A.S.T.M. pour point of an oil is the temperature at which flow ceases under specified cooling conditions. Pour-point depressants, as the name implies, lower the temperature at which this cessation of flow occurs. These pour point depressants cause the wax to separate in a micro-crystalline state and thus prevent the formation of the interlacing structure which entraps the oil and prevents its flow.

Viscosity-Index Improvers

Viscosity-index improvers are high-molecular-weight polymers which are usually added to the oil in percentages of 5 per cent or higher. The resulting solutions are colloidal in nature and show very good viscosity-temperature characteristics. The colloidal material present raises the viscosity of the mineral oil in which it is dispersed and this viscosity is relatively little affected by temperature change, unless the temperature reaches a level at which the material goes into true solution. This necessitates depolymerization of the additive material due to heat. Two of the most common materials now used as viscosity-index improvers are polymers of isobutylene or methacrylic esters.

Industrial Oils

Straight mineral oils when used for circulating, hydraulic or turbine systems in some cases show rather rapid oxidation or allow rusting to take place. These troubles were magnified during the past years as a result of accelerated production and lack of time for proper maintenance. This led to the widespread use of anti-oxidants and rust inhibitors in many industrial oils.

Straight mineral oils have been in normal use where operating conditions are not considered severe and where they are subject to a certain amount of oxidation. The dissolved oxidation products have the ability to act as rust inhibitors. Therefore, we might say after a short period of operation in a steam turbine, a good-quality straight mineral oil will develop enough inhibitor within itself to prevent rusting in the turbine system. However, if this oxidation continues, as it normally will, other disadvantages will appear, such as the possible formation of sludge. As there is no known way of controlling the extent of this oxidation, it must be prevented from taking place, by the use of oxidation inhibitors. This will, of course, prevent the formation of this more or less natural rust inhibitor, and thus necessitate the addition of the second additive to protect against rusting when water is present.

Available data on the operation of additive oils is quite striking because most case histories have been obtained on operating units which were severe with respect to oxidation or rusting when straight mineral oils were used. An actual example may be cited where a straight well-refined mineral oil outlived its usefulness in from three to six months in a steam-turbine system. When this system was cleaned and refilled with a rust- and oxidation-inhibited turbine oil, there was no evidence of oil deterioration or rusting of the turbine parts after four years of service. On the other hand, there are available records of similar steam turbines operating for over fifteen years on the original filling of uninhibited straight mineral oil. It would be hard to justify the use of additive-type oils in the latter case. The difference in the two cases stated is probably tied in with operating conditions.

The conditions under which the oil operates have a marked effect on the life of the oil. In general, additives used in these double-inhibited oils are not soluble in water. However, when they are contacted with excessive quantities of water, the additives may be removed by virtue of their surface activity; that is to say, the additives tend to concentrate at the interface between the oil and water and thus may be removed by the separated water. Over long periods of time, additive oils exposed to such an extraction process may not show the normal differential over straight mineral oils in all cases. Operating conditions, such as wet or dry operation, and methods of water separation must be taken into consideration. Rust inhibitors, in general, though they have proved very helpful in many instances are particularly susceptible to removal by adsorption on water droplets and their subsequent removal from the system will naturall shorten their effective life. Thus, it can not be assumed that the addition of a rust inhibitor to an oil will guarantee the absence of rusting in the system. The proper cure for rusting conditions is to remove the cause; that is, to prevent the entrance of water into the system in so far as possible. The rust inhibitor is then included in the oil as extra ensurance.

Anti-oxidants are included in many industrial oils to prevent the formation of acidic materials due to the action of air or oxygen on the oil. A great many labora-

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tory tests have been devised to evaluate the ability of an anti-oxidant to perform this function. The most prominent of these at the present time is the A.S.T.M. Turbine Oil Oxidation Test. This test was published by the A.S.T.M. some three years ago, but due to recognized weaknesses in the test, it has never been adopted as standard. Like many other laboratory oxidation tests, it is of considerable value in development work, but of questionable value as a specification requirement. It is quite possible to prepare an inhibited oil which will appear outstanding on the A.S.T.M. Turbine Oil Oxidation Test, but which will give poor service in field operation. For example, a base oil of inferior oxidation stability can be compounded with a water soluble oxidation inhibitor and the resulting A.S.T.M. Turbine Oil Oxidation Test will be excellent; whereas the service life in a turbine operating under wet conditions will be extremely short. Therefore, in using this test, knowledge of the materials is necessary to develop a complete picture.

Because of the many instances where water cannot be eliminated from a lubricating system such as a steam turbine or a steel-mill lubrication system, the ability of an oil to separate from water is a very desirable characteristic. Much time has been spent in an effort to develop a laboratory test which can be used to evaluate this characteristic with a fair degree of accuracy. To date, no satisfactory results have been obtained although the steam emulsion test is sometimes used. This test can be very misleading, because there are many cases where an oil with a high steam emulsion probably will separate from water with little or no difficulty. At present, service testing in field units is the only reliable method for determining this characteristic of the oil. As separation from water is retarded by the presence of oxidation products in the oil, the use of anti-oxidants has helped to a great extent in maintaining good water-separation characteristics.

Industrial Gear Oils

Oils for industrial gear lubrication must have good oxidation stability to ensure long service life. They must have the ability to prevent wear and be capable of giving low power losses. Straight mineral oils can be found which are capable of giving long service life, but where loads are heavy, fail from a standpoint of wear prevention and friction losses. Here again we turn to additives to make up for this natural lack in straight mineral oils. There are various types of additives available which are of great benefit in reducing wear and lowering friction losses in oils of this type. They vary from simple oiliness agents of the fatty-acid and ester type up through the so-called chemical polishing agents which depend on mild chemical action, to the very highly reactive extreme-pressure additives of the sulphur-chlorine type. Laboratory tests again failed to evaluate these additives, and service testing is always used as a guide to final formulation. Some laboratory equipment, particularly that which is designed to simulate field service as nearly as possible, is invaluable in establishing fundamental data that is indicative of the characteristic classes of additives. In this way, the laboratory equipment may be used as a screening test. The development of additives for this purpose is a long and painstaking process because many of the materials which prevent wear are, by their chemical activity, promoters of oxidation. This catalytic effect is not always easy to detect, and long field service tests are necessary before general acceptance of the compounded gear oil can be obtained.

Industrial and Railroad Steam Cylinder Oils

Because of their low volatility and inherent resistance to oxidation, Pennsylvania cylinder oils, with or without fatty-oil compounding have been used for many years in the lubrication of steam cylinders. Present day development is directed toward oils which will render superior lubrication under both wet and dry steam conditions, particularly where alwaline carry-over from the boiler water is present. Alkali from the boiler water reacts with fatty compounding to form soaps which are very effective in washing the lubricating film from the cylinder wall. Chemical additives have been developed which will give the necessary emulsification and preferential-wetting characteristics to the steam cylinder oil, yet will not be susceptible to reaction with alkaline carry-over. Also looking ahead at the ever-decreasing supply of Pennsylvania oil, suitable additives must be developed for the same purpose which will give the satisfactory properties to oils from other crude sources.

Industrial Railroad Diesel Engines

Straight mineral oils, and those containing oxidation inhibitors, and in some cases film-strength agents, have for some time given complete satisfaction in industrial and railroad Diesel operation. Recently the use of the detergent-type oils has been considered. Such oils are in use in many installations. Comparative tests under service conditions on railroad Diesels between these two types of oils have, in many cases, failed to show outstanding superiority for either type, but with the present trend towards increasing the power output of Diesel units, protection against wear and the maintenance of clean engines will undoubtedly become increasingly difficult. The problem is greatly complicated by the varied operating conditions encountered on the railroad. This service varies from high-speed passenger trains and low-speed freights where loads are likely to be high, down to the intermittent switch engine service where the engine operates at a low percentage of its rated capacity. The increasing power output of railroad Diesel engines will bring about increases in piston temperatures and this will increase the duty on the oil. Detergent oils may be necessary to satisfy these difficult service conditions and maintain clean conditions.

Previous to the war, various types of automotive Diesels required many different oils. During the war, with the widespread use of Diesels in the Armed Services and the problem of supply in the field, the so-called "all purpose" Diesel oil made its appearance. In addition to the fact that this oil had to be satisfactory for the variety of Diesels in service, as a matter of convenience it also had to meet the requirements for spark-ignition engines. These oils of the 2-104B and Navy 9000 Type proved so satisfactory during the war that they are now having more widespread use. We may call them heavy-duty engine lubricating oils having excellent oxidation stability and full detergent qualities.

Aviation Engine Oils

Aviation engine oil produced during the war was almost entirely for the Armed Services, and was a non-additive oil. The high quality of this aviation lubricating oil was obtained by careful selection of crude sources and the most modern and exacting refining methods. It appears that at the present time we have about reached the ultimate in quality by these methods and any further betterment of quality will have to be attained by the use of additives, unless new refining

methods and techniques, now unknown, are developed.

The discussion of the use of pour-point depressants had been reserved for this section on aviation oils because their most prominent use is in engine lubricating oils. We previously stated that the compounds classed as pour point depressants are added to change the characteristics of separated wax and to prevent the formation of interlacing crystals which retard the flow of oil. Such additives have been known for some time, but they were subject to a phenomenon known as pour-point reversions. If an oil containing a pour-point depressant is put through a cycle of temperature changes; that is, heated and cooled a number of times, we find that the temperature at which flow no longer occurs is apparently considerably higher. This means that a 0 deg. F. pour-point oil in storage where it is subject to temperature cycles may actually solidify at several degrees above its pour point. Newer additives are available that minimize this effect, which seems to be a function not only of the nature of the additive, but also of the rate of temperature change in the cycle and the character and amount of wax present in the oil.

Viscosity Index Improved Oils

Although the use of viscosity-index improvers has been very limited in combustion engine oils, it has been widespread in special hydraulic fluids. Hydraulic equipment which must function over a very wide range of temperature demands an oil which will show the least possible change in viscosity with temperature. This demand was illustrated by the Army Air Forces during the past war. Much of the equipment on planes, including landing gear, control surfaces, and some armament is operated by hydraulic mechanisms. Planes were required to take off from tropic or desert fields and, within a short space of time, reach high altitudes and have all hydraulic oils operate in a positive manner from start to end of the flight. The temperature range involved was in many cases from 140 deg. F. above 0 to more than 60 deg. F. below 0. Satisfactory fluids were made for this application from highly refined mineral oil containing oxidation inhibitors and polymer additives which gave a viscosity index in excess of 200. Viscosity-index improvers are not use to any great extent in industrial hydraulic oils because the temperature variation is not sufficient to justify their cost.

Where it is necessary to meet extremes in temperature operation, there may be an advantage in using this material in engine oils. There are some definite disadvantages, however, which must be considered. These additives are high-molecular-weight compounds approaching colloidal dimensions. Under hard service and heavy shearing conditions, these molecules tend to rupture into smaller units and thus cause a permanent reduction in viscosity. This reduction may in some cases amount to as much as 30 per cent, and carries with it the danger of decreasing the viscosity of the lubricating oil below that required for safe operation. At the present time, all of the known additives of this type are very costly, and to produce oils containing them would cost considerably more than the present oils of the 100 viscosity-index range. Trends in future design and operation may dictate their use regardless of cost and sufficient experience has been obtained to enable the petroleum industry to make such oils in quantity when the demand arises.

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HYDRODYNAMIC LUBRICATION OF SLEEVE BEARINGS SUBJECT TO VARYING LOADS.

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Introduction

THE theory of hydrodynamic lubrication of bearings stems from the analysis which Osborne Reynolds[1] originally developed to explain the results of Beauchamp Tower's[2] experiments on the lubrication of certain partial bearings. Reynolds derived the differential equation relating the pressure at any point in the oil film between two relatively moving solid surfaces to its position in the film, to the relative velocity of the surfaces and to the viscosity of the oil. The most significant result of this theory is the development of the principle of the converging wedge. According to this picture, a positive pressure can develop in the oil film between two solid surfaces so long as the two are converging. Owing to its viscosity the oil is being continually drawn into the converging portion of the wedge by the moving surface and due to the lessened space through which to escape it builds up a definite pressure in this region. This internal pressure serves as a head to force the oil out at a faster rate through the narrower clearance at the trailing edge of the film and at the sides, and as a back pressure to lessen the rate of flow in at the wider entering clearance. It adjusts itself to equalize these two flows. Under proper conditions this pressure may amount to ten thousand pounds per square inch or more, and serves very effectively to keep the two bearing surfaces separated against the action of a considerable applied load. This prevents metallic contact with resultant reduction of friction and wear.

Reynolds was only able to integrate his equation and obtain numerical solutions for certain limited cases, which included the bearings of Tower's experiments. Michell[3] applied Reynolds' equation to rectangular plane surfaces and he and Kingsbury independently developed the pivoted shoe thrust bearings which bear their names. Sommerfeld[4] solved Reynolds' differential equation for the case of the journal or sleeve bearing, both partial and full, and his solution has been the basis for most design work ever since. Sommerfeld's theory for sleeve bearings has been confirmed and extended by Harrison[5], Boswall[6], Muskat and Morgan[7 8 15] and others. Some of these analyses take account of the leakage of the oil from the ends of the bearings while others do not.

All of these analyses assumed that the center of the journal was stationary inside the bearing, its position being determined by the static equilibrium between the applied load and the resultant of the oil film pressures. This position will be different for different values of the applied load. Hence, if the load varies during operation the position of the journal center may be expected to shift. However, this very motion will produce additional pressures in the oil film owing to the oil being squeezed out on the side of the bearing ahead of the journal's motion and being sucked in behind it. As a result the balance at every instant of all the oil film pressures against the instantaneous applied load is a somewhat more involved problem than that solved by Reynolds and Somerfeld. It is, however, perfectly soluble. This more general problem was first investigated by Harrison[9] and later worked out rather completely by Swift[10]. Robertson[11] and Orloff[12] have also studied certain aspects. Swift's work was published in a British civil engineering journal and hence has escaped the attention of most mechanical engineers in this country. Also Swift's derivation is rather long and involved. It has therefore seemed worthwhile to the author to derive in the present paper the necessary equations in a simpler and more familiar form which bring out more clearly the various factors that produce pressures in the oil film. The principal results, together with some new conclusions, will also be drawn from these equations.

The Differential Equation

The derivation of the differential equation for the situation where the shaft center is moving inside a sleeve bearing will be based on classical hydrodynamic theory and parallels that of the familiar Reynolds' equation for the pressure desiribution in the oil film of a bearing with a stationary shaft or journal. The usual assumptions occurring in hydrodynamic viscous film theory are made.*

Referring to Fig. 1, the thin lubricant film is developed so that one of the bounding surfaces is plane. This is taken as parallel to the X Z plane. The distance between the two surfaces, parallel to the y-direction, is called h which in general is a function of x and z. The plane surface is considered to have velocity components V_x, V_y, V_z parallel to the X, Y, Z axes and relative to the other surface which is considered as fixed.

Now consider the element of volume of infinitesimal cross-section dx dz and height h. The net flow out of this volume in the x— and z— directions is given by*

$$\frac{\partial}{\partial x}\left[\frac{V_x}{2}h - \frac{h^3}{12\mu}\cdot\frac{\partial p}{\partial x}\right]dx\,dz + \frac{\partial}{\partial z}\left[\frac{V_z}{2}h - \frac{h^3}{12\mu}\frac{\partial p}{\partial z}\right]dx\,dz$$

where p is the pressure at any point X, Z in the oil film and μ is the viscosity of the lubricant. Since the fluid is incompressible this must equal the rate at which this

* See any standard text on the theory of lubrication, for instance A. E. Norton: Lubrication, McGraw-Hill, 1942, Chap. V, Sec. 43.

* See Norton, ibid, Chap. IX, Sec. 78.

volume is changing or $-V_y dxdz$. Hence

$$\frac{\partial}{\partial x}\left(\frac{h^3}{\mu}\frac{\partial p}{\partial x}\right)+\frac{\partial}{\partial z}\left(\frac{h^3}{\mu}\frac{\partial p}{\partial z}\right)=6\frac{\partial}{\partial x}(hV_x)+6\frac{\partial}{\partial z}(hV_z)+12V_y \qquad (1)$$

This is the generalized form of the usual Reynolds' equation for the pressure developed in a thin film between two surfaces in relative motion and is applicable to any bearing under any conditions of operation.

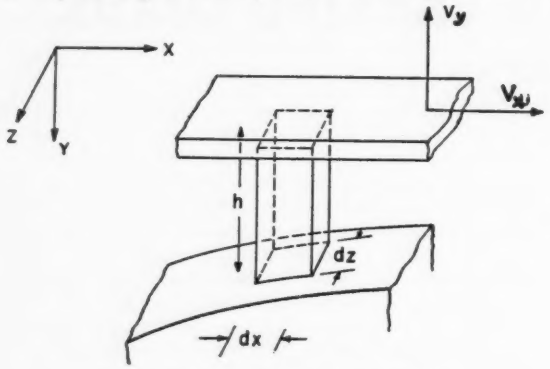

Fig. 1. Volume Element of an Oil Film

Equations for Pressures, Load and Friction

Now we apply equation (1) to the case of a sleeve bearing in which the center of the rotating journal is in motion relative to the center of the bearing. In Fig. 2 the origin is placed at the center of the bearing 0_b and all motions are referred to axes fixed with respect to the bearing. The principal quantities shown in Fig. 2

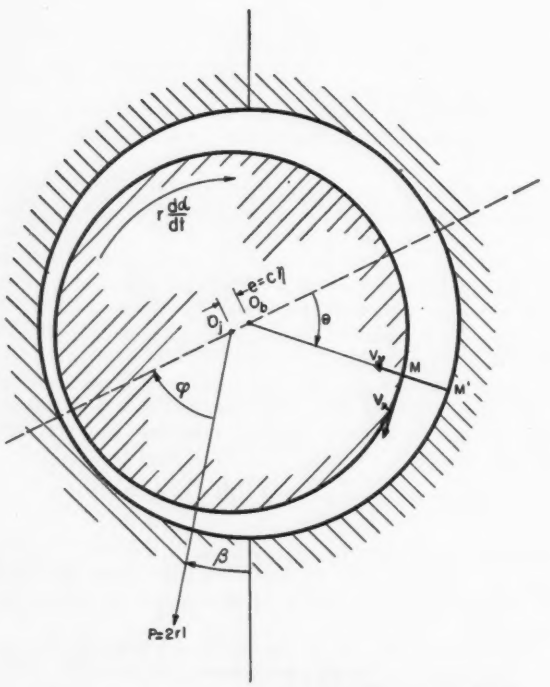

Fig. 2. Section of a Sleeve Bearing Showing Principal Quantities of Interest

are defined as follows:

r = radius of journal or bearing

l = axial width of bearing

c = radial clearance or difference in radii of bearing and journal

e = the distance between the center of journal and bearing, called the eccentricity

$\eta = \frac{e}{c}$, called the eccentricity ratio

η_{max} = maximum value of η during a cycle

η_0 = value of η given by the Sommerfeld equation

$\zeta = \frac{\eta}{(1-\eta^2)^{1/2}}$, called the eccentricity function

Θ = angular position of any point in the oil film measured from the maximum film-thickness end of the line-of-centers

α = angular rotational displacement of journal relative to the bearing

β = angle between the direction of the load and a fixed point on the bearing measured in the direction of rotation

ϕ = angle between the direction of the load and the minimum film thickness end of the line-of-centers measured in the direction of rotation

t = time

$\tau = 2\pi N t$, a dimensionless time or crank angle

$\frac{d\alpha}{dt}$ = instantaneous angular velocity of journal

N_j = average angular velocity of journal in revolutions per unit time, a constant

N_p = average frequency of rotation or oscillation of the load in revolutions or cycles per unit time

μ = absolute viscosity of the lubricant

p = pressure at any point, Θ, in the oil film

p_0 = pressure in the oil film at $\Theta = 0$

W = total radial load applied by the shaft to the oil film

$P = \frac{W}{2rl}$ = load per unit projected area of bearing

P_0 = maximum amplitude of P for a periodic load

$S = \left(\frac{r}{c}\right)^2 \frac{\mu N_j}{P}$, often called the Sommerfeld variable

$S^1 = \left(\frac{r}{c}\right)^2 \frac{\mu N_p}{P}$

S_0, S_0^1 = values of S and S^1 corresponding to $P = P_0$

s_j, s_b = shear stress on surface of journal and bearing respectively

f_j, f_b = friction coefficient on the journal and bearing respectively

In applying equation (1) to the sleeve bearing in question, the x-direction is taken as the principal direction of motion which is the tangential direction and the z-direction is taken as the axial direction of the bearing. In this case V_z is ordinarily zero and the usual geometrical transformations $x = r\Theta$ and $h = c(1+\eta\cos\Theta)$ are made so that equation (1) becomes:—

$$\frac{1}{r^2}\frac{\partial}{\partial\Theta}\left[\frac{c^3}{\mu}(1+\eta\cos\Theta)^3\frac{\partial p}{\partial\Theta}\right]+\frac{\partial}{\partial z}\left[\frac{c^3}{\mu}(1+\eta\cos\Theta)^3\frac{\partial p}{\partial z}\right]$$
$$-6\frac{1}{r}\frac{\partial}{\partial\Theta}\left[c(1+\eta\cos\Theta)V_x\right]=12V_y \qquad (2)$$

This is the most general form of the differential equation for the bearing in question, but its solution is extremely complicated. If, however, the following as-

sumptions are made, namely that

(a) the pressure is independent of z, i. e., side leakage is neglected, and

(b) the viscosity is constant throughout the oil film,

then equation (2) becomes

$$\frac{1}{r^2}\frac{d}{d\Theta}\left[c^3(1+\gamma\cos\Theta)^3\frac{dp}{d\Theta}\right]-6\mu\frac{1}{r}\frac{d}{d\Theta}\left[c(1+\gamma\cos\Theta)\cdot V_x\right]=12\mu V_y \quad (3)$$

This is the equation to be solved. If the term on the right-hand side is neglected, which has generally been done in the past, the solution is simply that obtained by Sommerfeld.

First, it is necessary to express the velocities V_x and V_y in terms of the variable Θ. Under a varying load the center of the journal 0_j will move relative to the center of the bearing 0_b. If the polar coordinates of 0_j relative to 0_b are $e = c\eta$ and $\beta + \phi$ then its instantaneous radial and tangential velocities are c. $\frac{d\eta}{dt}$ and $c\eta\frac{d}{dt}(\beta+\phi)$.

Resolving these perpendicular and parallel to the direction Θ we have respectively:—

$$c\frac{d\eta}{dt}\sin\Theta - c\eta\frac{d}{dt}(\beta+\Theta)\cos\Theta$$

and $$c\frac{d\eta}{dt}\cos\Theta + c\eta\frac{d}{dt}(\beta+\phi)\sin\Theta$$

In addition every point on the surface of the shaft has a tangential velocity $r\frac{da}{dt}$ due to its instantaneous rotation about its own center. Hence

$$V_x = r\frac{da}{dt} + c\frac{d\eta}{dt}\sin\Theta - c\eta\frac{d}{dt}(\beta+\phi)\cos\Theta$$

$$V_y = c\frac{d\eta}{dt}\cos\Theta + c\eta\frac{d}{dt}(\beta+\phi)\sin\Theta \quad (4)$$

which are the velocities of the point M relative to the point M^1 in Fig. 2. Substituting these in equation (3):—

$$\frac{d}{d\Theta}\left[(1+\gamma\cos\Theta)^3\frac{dp}{d\Theta}\right]=6\left(\frac{r}{c}\right)^2\mu\frac{d}{d\Theta}\left[(1+\gamma\cos\Theta)\cdot\left(\frac{da}{dt}+\frac{c}{r}\frac{d\eta}{dt}\sin\Theta-\frac{c}{r}\eta\frac{d}{dt}(\beta+\phi)\cos\Theta\right)\right]+12\left(\frac{r}{c}\right)^2\mu\cdot\left[\frac{d\eta}{dt}\cos\Theta+\eta\frac{d}{dt}(\beta+\phi)\sin\Theta\right] \quad (5)$$

Integrating equation (5) with respect to Θ and rearranging terms:—

$$(1+\gamma\cos\Theta)^3\frac{dp}{d\Theta}=6\left(\frac{r}{c}\right)^2\mu\frac{da}{dt}\cdot(1+\gamma\cos\Theta)+\left[12\left(\frac{r}{c}\right)^2+6\left(\frac{r}{c}\right)(1+\gamma\cos\Theta)\right]\mu\frac{d\eta}{dt}\sin\Theta-\left[12\left(\frac{r}{c}\right)^2+6\left(\frac{r}{c}\right)(1+\gamma\cos\Theta)\right]\mu\eta\frac{d}{dt}(\beta+\phi)\cos\Theta+C \quad (6)$$

where C is a constant of integration to be evaluated later. Since $(\frac{r}{c})$ is always large, then $6\left(\frac{r}{c}\right)(1+\eta\cos\Theta)$ is always negligible compared to $12\left(\frac{r}{c}\right)^2$ and these terms can be dropped. Combining the terms in $\cos\Theta$ and dividing both sides by $6\left(\frac{r}{c}\right)^2\mu(1+\eta\cos\Theta)^3$, equation (6) becomes

$$\frac{1}{6\left(\frac{r}{c}\right)^2\mu}\frac{dp}{d\Theta}=\frac{1}{(1+\gamma\cos\Theta)^2}\frac{d}{dt}(\alpha-2\beta-2\phi)+2\frac{d\eta}{dt}\cdot\frac{\sin\Theta}{(1+\gamma\cos\Theta)^3}+\frac{C'}{(1+\gamma\cos\Theta)^3} \quad (7)$$

In integrating this equation it will be assumed, following Sommerfeld, that a complete oil film exists around the bearing and that it is capable of supporting negative pressures. The limitations of this assumption are well known and will not be discussed here except to note that it is probably more valid in this, the dynamic situation, where any given region of the oil film is only subjected to negative pressure for a short interval of time. If the above assumption is not made, then equation (7) must be integrated graphically as was done by Howarth[13] in the case of the simple Reynolds equation.

While the equation under these assumptions can be integrated in a straightforward manner, it is more convenient to employ the substitution originally suggested by Sommerfeld[4], namely

$$1+\eta\cos\Theta=\frac{1-\eta^2}{1-\eta\cos\gamma} \quad (8)$$

where γ has the range 0 to 2π corresponding to 0 to 2π for Θ. This substitution is applied to the first and third terms on the right-hand side of equation (7) before integrating, but the second term is more easily integrated directly in terms of Θ. In terms of γ integration of equation (7) then yields

$$\frac{1}{6\left(\frac{r}{c}\right)^2\mu}(p-p_0)=\frac{d}{dt}(\alpha-2\beta-2\phi)\frac{1}{(1-\eta^2)^{3/2}}(\gamma-\eta\sin\gamma)+2\frac{d\eta}{dt}\cdot\frac{1}{2\eta}\left[\frac{1}{2\eta(1-\eta^2)^2}\cdot(1-\eta\cos\gamma)^2-\frac{1}{(1+\eta)^2}\right]+C'\cdot\frac{1}{(1-\eta^2)^{5/2}}(\gamma-2\eta\sin\gamma+\tfrac{1}{2}\eta^2\sin\gamma\cos\gamma+\tfrac{1}{2}\eta^2\gamma) \quad (9)$$

where p_0 is the pressure at the point $\gamma = \Theta = 0$. The constant C^1 is evaluated by the fact that the pressure 1 rise from $\gamma = \Theta = 0$ around to $\gamma = \Theta = 2\pi$ is zero, whence

$$C^1 = -\frac{2(1-\eta^2)}{2+\eta^2}\frac{d}{dt}(a-2\beta-2\phi) \quad (10)$$

Substituting this value for C^1 in equation (9) and reintroducing Θ we obtain:

$$p-p_0=6\left(\frac{r}{c}\right)^2\mu\cdot\frac{2\eta(2+\eta\cos\Theta)\sin\Theta}{(2+\eta^2)(1+\eta\cos\Theta)^2}\cdot\frac{d}{dt}(\alpha-2\beta-2\phi)+6\left(\frac{r}{c}\right)^2\mu\cdot\frac{1}{\eta}\left\{\frac{1}{(1+\eta\cos\Theta)^2}-\frac{1}{(1+\eta)^2}\right\}\frac{d\eta}{dt} \quad (11)$$

for the instantaneous pressure at any point Θ in the oil film.

In equation (11) the first term represents the pressure developed by the tangential motion of the surface of the journal relative to the surface of the bearing. This may be called the "wedge-film" component of the pressure. The term $\frac{da}{dt}$ (or $2\pi N_j$ if the rotation is at constant speed) is the pressure due to rotation of the journal about its own center, and is the only term in the familiar expression originally derived by Sommerfeld[4]. The term $-2\frac{d}{dt}(\beta+\phi)$ is due to tangential motion of the journal center about the center of the bearing.

The second term in equation (11) represents the pressure developed in the oil film due to motion of the journal and bearing surfaces toward and away from each other, and may be called the "squeeze film" component as suggested by Underwood[14]. This motion is due to radial motion of the journal center with respect to the bearing center.

The integral of the pressure over the entire journal must equal the instantaneous applied load. Let the magnitude of this load be $W = 2\,Prl$ and its direction with respect to a fixed line on the bearing be β. (See

Fig. 2.) Define the angle ϕ as the angle between the directions of the load and the minimum film thickness end of the line-of-centers. Then the load components normal and parallel to the line-of-centers are:

$$2\,Prl\,\sin\varphi = +\int_0^{2\pi}\int_0^1 (p - p)_0 \sin\theta\, r\, d\theta\, dz \qquad (12)$$

$$2\,Prl\,\cos\varphi = -\int_0^{2\pi}\int_0^1 (p - p_0)\cos\theta\, r\, d\theta\, dz$$

Substituting for $(p - p_0)$ and integrating:—

$$P\sin\phi = 3\left(\frac{r}{c}\right)^2\mu \cdot \frac{d}{dt}(a - 2\beta - 2\phi) \cdot \frac{2\pi\eta}{(2+\eta^2)(1-\eta^2)^{1/2}} \qquad (13)$$

$$P\cos\phi = 3\left(\frac{r}{c}\right)^2\mu \cdot \frac{d\eta}{dt} \cdot \frac{(1-\eta^2)^{3/2}}{2\pi}$$

Divide both sides by $12\pi^2\left(\frac{r}{c}\right)^2\mu N_j$ where N_j is the nominal or average number of revolutions per unit time of the journal with respect to the bearing, and define the Sommerfeld variable in the usual manner as $S = \left(\frac{r}{c}\right)^2\mu N_j$ •

Then equations (13) become

$$\frac{\eta}{(2+\eta^2)(1-\eta^2)^{1/2}} \cdot \frac{1}{2\pi N_j}\frac{d}{dt}(a - 2\beta - 2\phi) = \frac{1}{12\pi^2 S}\sin\phi \qquad (14)$$

$$\frac{1}{(1-\eta^2)^{3/2}} \cdot \frac{1}{2\pi N_j}\frac{d\eta}{dt} = \frac{1}{12\pi^2 S}\cos\phi$$

where S and β are arbitrary functions of the time. The first equation contains the component of the load carried by the wedge-film component of the pressure and the second equation contains that carried by the squeeze film component.

Before discussing solutions of the above equations, it is desirable for completeness to give the corresponding friction equations. The general expressions for the shear stresses at the surfaces of the journal and bearing respectively due to the viscous drag of the oil film* are:—

$$s_j = \frac{\mu V_s}{h} + \frac{h}{2r}\frac{\partial p}{\partial\theta} \qquad (15)$$

$$s_b = \frac{\mu V_s}{h} - \frac{h}{2r}\frac{\partial p}{\partial\theta}$$

The friction force and friction coefficient are obtained by substituting for p from equation (11) and integrating over the whole area of the oil film. Muskat and Morgan[7] have avoided the cumbersome integrations involved by first integrating equations (15) by parts after substituting $h = c(1 + \eta\cos\Theta)$ and then noting that one of the resulting terms is directly proportional to W sin ϕ. The expression for the friction force is then found independently of any particular pressure distribution. When these operations are carried out one obtains for the friction coefficients on the journal and bearing respectively the following equations:—

$$\frac{r}{c}f_j = \frac{\eta}{2}\sin\phi + \frac{2\pi^2 S}{(1-\eta^2)^{1/2}} \qquad (16)$$

$$\frac{r}{c}f_b = -\frac{\eta}{2}\sin\phi + \frac{2\pi^2 S}{(1-\eta^2)^{1/2}}$$

Once η and ϕ are determined from equations (14) for a particular type of loading, the friction coefficients can be determined from equations (16).

* See Norton, ibid, Chap. VII, Sec. 61.

Discussion

Equations (14) and (16) constitute the working equations for problems of bearings subjected to varying loads. When the variation of the magnitude, P, of the load per unit area and of its direction, β, with time are known, then equations (14) can be solved, in theory at least, to give the instantaneous position of the journal center in terms of the coordinates, η and ϕ. The maximum value that η attains is of principal interest since that indicates the minimum value of the oil film thickness and hence the margin of safety of operation.

Some interesting deductions can be drawn from equations (14) immediately. First, it should be noted that in these equations the quantities r, c, μ, N_j and P appear only in combination $\left(\frac{r}{c}\right)^2\frac{\mu N_j}{P}$ just as they do for the simple Sommerfeld equation. (The one exception to this is N_j but as it only appears when associated with the time, t, the combination can be treated as a dimensionless time, $2\pi N_j\, t$; hence the solution is independent of the journal speed per se.)

Secondly, in view of the occurrence of the dimensionless quantity S, problems not only of varying load but also of varying viscosity, such as when a bearing is heating up, can be handled by means of these equations. Problems of varying shaft speed can also be handled through the proper expression for $\frac{da}{dt}$

Certain special cases can be simply discussed and are of some interest. First is the case of a load of constant magnitude rotating at a uniform speed. In this case S is constant, $\frac{d\beta}{dt} = 2\pi N_p$ where N_p is the angular speed of the load in revolutions per unit time and if the shaft speed is constant then $\frac{da}{dt} = 2\pi N_j$. N_p and N_j have the same sign when taken in the same direction. Then equations (14) become

$$\frac{\eta}{(2+\eta^2)(1-\eta^2)^{1/2}}\cdot\left[1 - 2\frac{N_p}{N_j} - \frac{2}{2\pi N_j}\frac{d\varphi}{dt}\right] = \frac{1}{12\pi^2 S}\sin\varphi \qquad (17)$$

$$\frac{1}{(1-\eta^2)^{3/2}}\cdot\frac{1}{2\pi N_j}\frac{d\eta}{dt} = \frac{1}{12\pi^2 S}\cos\varphi$$

If it is assumed that the journal center is at the equilibrium position for these particular conditions then η and ϕ are constant, their time derivatives vanish and the solutions of equations (17) are found immediately as

$$\varphi = \pm\frac{\pi}{2} \qquad (18)$$

$$\frac{\eta}{(2+\eta^2)(1-\eta^2)^{1/2}}\cdot\left(1 - 2\frac{N_p}{N_j}\right) = \pm\frac{1}{12\pi^2 S}$$

The positive signs in both equations are taken when N_p is less than $\frac{1}{2}N_j$ and the negative signs when N_p is greater than $\frac{1}{2}N_j$. From these equations we see that when $N_p = 0$, the second equation is simply the original Sommerfeld equation for a constant load in a fixed direction. As N_p increases up to $\frac{1}{2}N_j$ the eccentricity ratio for a given load increases. $N_p = \frac{1}{2}N_j$ represents a critical speed of load rotation. At this speed the eccentricity ratio becomes unity, i. e., the shaft touches the bearing under even the smallest loads. Conversely, a finite eccentricity may be assumed by a shaft whose

center is rotating at this speed under no load. This is the explanation of the phenomenon of "oil whirl". If N_p is greater than $\frac{1}{2} N_j$ a finite load can again be carried by the bearing, the size of the load for a given eccentricity increasing as N_p increases. Likewise, if N_p is opposite in direction to N_j a considerable load can be carried as equations (18) show. These cases have recently been discussed by Stone and Underwood[16]. If the journal center is not at the equilibrium position, then $\frac{d\eta}{dt}$ and $\frac{d\phi}{dt}$ are not zero and its motion is more complicated, consisting of orbits about the equilibrium position as a pole. These orbits are discussed by Swift[10].

Another special case of interest is that of a non-rotating shaft subjected to a reciprocating load, as in the case of a piston pin. In this case $\frac{d\alpha}{dt} = N_j = 0$ and $\frac{1}{dt}\frac{\beta}{} = 0$. Then equations (14) become

$$-2\frac{\eta}{(2+\eta^2)(1-\eta^2)^{1/2}}\frac{d\phi}{dt} = \frac{1}{6\pi}\frac{P}{\left(\frac{r}{c}\right)^2\mu}\sin\phi$$

$$\frac{1}{(1-\eta^2)^{3/2}}\frac{d\eta}{dt} = \frac{1}{6\pi}\frac{P}{\left(\frac{r}{c}\right)^2\mu}\cos\phi \qquad (18)$$

where P is still a function of the time. The general behavior can be most easily understood from the solution of a particular case, namely when the journal center moves along a straight line through the bearing center and parallel to the load line. In this case $\frac{d\phi}{dt} = 0$, the first of equations (18) vanishes and the second one becomes

$$\frac{\eta}{(1-\eta^2)^{1/2}} = \frac{1}{6\pi}\frac{1}{\left(\frac{r}{c}\right)^2\mu} P\,dt \qquad (19)$$

If the load is sinusoidal, i. e., $P = P_o \sin 2\pi N_p t$ where N_p is the frequency of the load, then equation (19) can be integrated to give the following expression for the maximum eccentricity ratio, η_{max}, in its path of the oscillating journal center:

$$\frac{\eta_{max}}{(1-\eta^2_{max})^{1/2}} = \frac{1}{12\pi^2 S'_o} \qquad (20)$$

where $S'_o = \left(\frac{r}{c}\right)^2 \frac{\mu N_p}{P_o}$. This equation bears some formal resemblance to the Sommerfeld equation and indicates a considerable load capacity for non-rotating shaft so long as the load is oscillating. In this case the bearing assembly is behaving like a hydraulic cylinder, the shaft being the piston. The oil film in front of the shaft offers resistance due to its viscosity and requires time to be squeezed out. This viscous resistance supports the load.

The more general cases of varying loads on rotating shafts require a knowledge of how the load varies with the time. Each case must be solved individually and few generalizations can be made. However, there is one transformation of equations (14) which is useful and has much to recommend it. If we define a new dimensionless variable, ζ, called the eccentricity function by the relation

$$\zeta = \frac{\eta}{(1-\eta^2)^{1/2}} \qquad (21)$$

and in addition introduce the dimensionless time $\tau = 2\pi N_p t$, then in terms of them equations (14) become

$$\frac{1+\zeta^2}{2+3\zeta^2}\zeta \cdot \frac{N_p}{N_j}\frac{d}{d\tau}(a-2\beta-2\phi) = \frac{1}{12\pi^2 S}\sin\phi$$

$$\frac{N_p}{N_j}\frac{d\zeta}{d\tau} = \frac{1}{12\pi^2 S}\cos\phi \qquad (22)$$

The quantity ζ has several advantages in the solution of equations (14), namely:—

(a) It simplifies the equations somewhat, particularly the second one.

(b) It spreads out the curve of eccentricity versus load in the vicinity of $\eta = 1$ which is the critical region of interest.

(c) It has theoretical significance in being the quantity whose time rate of change is proportional to the squeeze-film component of the load, as the second of equations (22) shows.

(d) A plot of the quantity $\frac{1+\zeta^2}{2+3\zeta^2}\zeta$ shows that it is very closely linear in ζ for large values of ζ. This means that in the case of constant load, ζ is linearly proportional to the load. It also means that for calculations under periodic loads a further simplification is possible. For periodic loads let $P = P_o\, p(\tau)$ where P_o is the maximum value of the load during the cycle and $p(\tau)$ is any periodic function having a maximum amplitude of unity. Then if $S_o = \left(\frac{r}{c}\right)^2 \frac{\mu N_j}{P_o}$ be solved in terms of the product $S_o \cdot \zeta$ rather than ζ alone. Hence the solution depends only on the form of $p(\tau)$ and is independent of the particular value of S_o. This saves computation since performance for all loadings having the same wave form, $p(\tau)$, can be deduced from a single solution for the maximum of the product $S_o \cdot \zeta$, call it $(S_o \cdot \zeta)_{max}$ in equations (22) by means of the relation

$$S_o \cdot \zeta_{max} = (S_o \cdot \zeta)_{max} \qquad (23)$$

(e) Finally, it is easy to convert between ζ and η by the use of trigonometric tables since $\zeta = \tan(\sin^{-1}\eta)$.

Some study has been made of the shaft motion under several types of varying periodic loads using equations (22), the results of which are reported in detail elsewhere (17). The characteristics of the motion, including the maximum eccentricity, depend on how the load varies and insufficient cases have as yet been studied to draw any very definite conclusions. However, the following tentative ones appear from the work to date:—

(a) The load capacity calculated on this more exact basis is quite different from that calculated on the assumption of a constant load.

(b) It is usually greater than in the case of a constant load but not always so. It may be less in certain cases, particularly if load frequencies in the vicinity of half the shaft speed are present.

(c) The greater the frequency of the load relative to the shaft speed, the greater the load capacity.

(d) The more peaked the wave form of the varying load the greater the load capacity.

The above discussion indicates some of the salient points of equations (14) and the methods whereby they are applied in the case of a given type of loading. Their application to bearings whose loads vary with time should lead to a more accurate estimate of their load capacity than the current procedure of using empirical data on the performance of similar bearings that have operated satisfactorily in the past. This should be particularly true in the case of new types of loadings on which there is no previous service experience.

(*Continued on page 74*)

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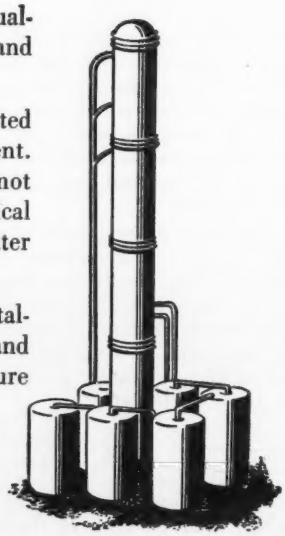

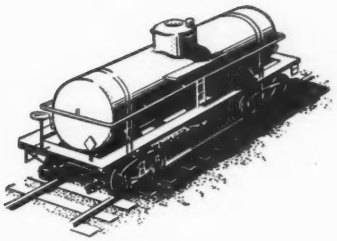

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(*Continued from page* 71)

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Swan-Finch Elects Two Officers

Ernest V. Moncrieff, formerly president of the Swan-Finch Oil Corporation, RCA Building, New York City, has been elected chairman of the Board, the company announced. At the same time, Howard F. Moncrieff, formerly vice-president in charge of sales, was elected president and chief executive officer. Both have been with the company for over 30 years.

Swan-Finch manufactures quality cutting oils, core oils and maintenance lubricants under the brand names *Safco* and *Motul.* The company, now in its 95th year, operates plants at Newark, Chicago and Detroit, and has distribution points strategically located from coast to coast and abroad.

Ernest V. Moncrieff

Howard F. Moncrieff

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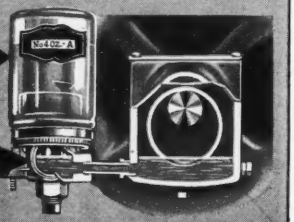

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Tyson Bearing Corp. Announces New Sales Appointments

Mr. H. I. Lewis of the Tyson Bearing Corporation, Massillon, O., has announced the following appointments and assignments in the Tyson Bearing Corporation as part of their extension program.

Mr. George C. McMullen, new Vice President in Charge of Sales, is widely recognized as an authority in the design and application of Anti-Friction Bearings.

Mr. W. H. Oexle joins the Tyson organization in the capacity of General Sales Manager. During the past twelve years, he has been with the L. S. Starrett Company of Athol, Mass., in sales and merchandising.

Mr. Herschel J. Deal, Vice President, will make his headquarters in Chicago in charge of the midwest territory.

Mr. Ivan C. Mann, formerly Manager of Replacement Sales, has been appointed Assistant Sales Manager.

*Coolants for Metal Working

By E. L. H. BASTIAN

Staff Engineer Shell Oil Co., Inc.

E. L. H. Bastian is Lubricant Staff Engineer for the Shell Oil Company, Inc., New York. After graduating from the Case School of Applied Science in 1931 with a B. S. degree in Mechanical Engineering, he studied at Wayne University, University of Michigan, Columbia University, and the John Huntington Polytechnic Institute. He began his career with Shell in 1936, and has become an authority on cutting fluids and emulsions used in precision metalworking. He is a member of the American Society of Tool Engineers, the American Society of Mechanical Engineers, the American Society of Metals, and the National Wire Association.

THE use of coolants in the metal working industry has its origin in man's earliest experience with sharp edged tools. Men who lived in caves and clothed themselves in the skins of beasts they killed with their weapons, fashioned those weapons by means of drops of water falling on heated flint stones to form a sharp cutting edge. Their very lives depended upon their skill in the use of coolants.

Probably every adult today remembers the old fashioned whetstone whereon water was employed as a coolant in the sharpening of tools and cutlery. Certainly every tool engineer knows of the early work of F. W. Taylor about 1885 in making the first practical demonstration of the effectiveness of water as a coolant in increasing the production efficiency of machine tools. By playing a stream of water on the tool in a turning operation he discovered that cutting speeds could be increased by about one-third. Since that time a tremendous amount of work in this field of metal working coolants and fluids, such as the research continually underway in Shell laboratories, has brought to use the cutting fluids and coolants we know today.

This development of modern products has entailed at least experimentally, many materials other than water which we naturally associate in our thinking with the subject of coolants. However, since the high efficiency as a cooling medium, of water, or water in conjunction with other materials, is indisputable, and since cooling to one degree or another is requisite to every process fluid used in metal cutting or working, this power will deal only with the important group of water mixtures or solutions used as coolants in metal working.

Under metal working we will consider only those processes involving a mechanical changing of shape or size of material, such as cutting, sawing, grinding, drawing, stamping, and to some extent rolling. It is recognized that there are other industrial processes in the metals industry wherein coolants, specifically water coolants, are employed. Such, for example, are quenching of ferrous and non-ferrous metals in water or water solutions, the use of water solutions in heat exchangers, and for other heat transfer purposes.

Before discussing the application of coolants in the metal working processes mentioned, it will probably be desirable to consider several things relative to coolants themselves, such as compositions of typical water soluble or emulsifiable materials, the preparation of aqueous coolants for use, their care, maintenance, and control in use, and the relative suitability of water coolants versus other types of fluids.

Regarding composition, while plain water (as used ployed as a coolant in metal cutting, the disadvantages of such coolants are well known. They rust work and by Taylor) or an alkaline water solution may be emmachines readily, and fail to provide other characteristics essential to modern machining practice.

Two important types of compounds have been developed for use with water in making water soluble or emulsifiable coolants for the metals industry. These are the so-called soluble oil and the paste type compound. The former is usually composed of mineral oil plus an emulsifying agent or soap plus a coupling agent. The emulsifier may consist of sulphonates, acid sludges, glycols, saponified phenols or naphthenic acid and the coupling agents may be alcohols of several types. The soluble oil may contain fatty oils, fatty acids, wetting out agents, active chemical additives, water softening agents, germicides, and some water itself. All such soluble oils are usually liquid, and mix readily with various proportions of water to form the coolant used at the machine. Although normally called soluble oils, they are not really soluble, but go into an emulsified state wherein tiny globules of oil are dispersed in the water. Under certain conditions, an invert emulsion may be formed wherein water globules are suspended in oil. While an invert emulsion is sometimes desirable for specific application, as in some types drawing operations, it is ordinarily to be avoided. This subject will be covered in more detail under preparation and care of coolants.

The paste type compounds are usually composed of combinations of various soaps, fatty oils, fatty acids, and

*Presented before New York York Section A.S.L.E.

water. They may contain mineral oils, other emulsifying agents, resins, active chemical additives, germicides, and solid pigment type fillers dependent upon the intended application of the coolant. The pastes usually mix well with water to form an emulsified coolant. The free fatty acid content is based on the application requirements.

Because of their constituents, the paste type compounds usually produce emulsions having a higher degree of lubricity than the emulsions secured from soluble oils. However, by proper formulation, the latter may be made to possess unusual properties for special applications.

Emulsions, whether made from soluble oils or paste type compounds, should be prepared carefully, as the preparation procedure has a great deal to do with the ultimate value of the emulsion as a coolant and lubricant. In the case of soluble oil emulsions, the oil should always be added to the water. This initial mix should be agitated throughly while the oil is being added to a quantity of water at least six to seven times the quantity of oil. After this initial emulsion has been made, additional dilution with water to any desired proportion. can be easily made. While for some soluble oils, hot (160° F.) water is necessary to secure best emulsions, in most cases cold tap water is entirely satisfactory. If, however, good agitation of the mix is not made while the oil is being added to the water, some of the soap combining with the water may cause a separation of mineral oil which accumulates as a permanent layer on top of the emulsion. If insufficient water is used in the initial mixing, or if the water is added to the oil, an invert emulsion may occur. Such an emulsion is characterized by a thick slimy appearance. While suitable for some drawing applications, invert emulsions are undesirable for most cutting and all grinding uses. In the latter application an invert emulsion would obviously load up the grinding wheel very quickly and cause trouble.

In mixing paste type compounds with water, it is generally desirable to use hot water, and always necessary to employ agitation, either hand paddle, mechanical, or live steam in order to secure a satisfactory mixture. This is particularly important where the coolant is to be used in a circulation system. If not throughly mixed, small particles of compound may deposit in system piping upon shutdown of machines. This could cause complete stoppage of a coolant line over a period of time. Where lightly pigmented compounds are used in circulating systems, this is even more important.

The characteristics of the water used in preparing emulsion coolant have an important bearing on the preparation procedure to secure a satisfactory emulsion. Soft lake and river waters, where available, present no problem. However, hard well waters (300-700 p.p.m. hardness) which sometimes contain minerals, salts, etc., make for some difficulty in preparing uniform, stable emulsions. Ordinary emulsions made with hard water tend to break readily, that is, separate into a stratified condition upon standing wherein a layer of oil or heavy creamy emulsion floats on the surface of a much leaner emulsion than was originally prepared. For many applications such separation is extremly detrimental to good coolant efficiency. In the case of grinding, severe wheel loading will result very quickly.

There are two methods by which water hardness may be overcome, either by special formulation of the soluble oil or by pre-treatment of the water. The first approach entails certain difficulties for the soluble oil manufacturer but has been accomplished. The pre-treatment of the water is a common practise in industry. Various commercial water conditioning agents are available, consisting usually of polyphospbate combinations. Ordinary tri sodium phosphate as a water conditioner is well known. The general rule for use of these materials is to add about 1.5 ounces per 100 gallons of water, per grain of hardness. This amount produces a soft water which emulsifies practically any soluble oil or compound readily. If the water hardness in p.p.m. (parts per million) is known, divide by 17 to secure the grain hardness. For example, a sample of well water has hardness of 340 p.p.m. This is equivalent to 20 grains hardness. To treat this water for the purpose of making good emulsions, it would be desirable to add about 2 pounds of water softner per 100 gallons of water. Hard well waters range from about 20 to 40 grains hardness. Soft lake, pond, and river waters may range from 3 to 10 grains hardness.

Water treatment should always be made prior to adding the soluble oil or compound.

Before an emulsion is put in the machine system for service, certain precautions should be taken to insure good operating results and reasonable service life. First among these is cleanliness. The importance of this point in handling emulsions cannot be overstated. The system itself should be thoroughly washed out and flushed. Deposits of any type should be removed particular attention being given to corners, angles, and pockets where these may have collected. Soluble oil emulsions are very susceptible to contaminants. If there may be any reason to suspect the presence of bacteria in the previous coolant contained in the system, a flush of the cleaned out sump with a germicidal solution would be in order before putting in the new coolant. These precautions will pay dividends in insuring maximum usefulness of the new emulsion and avoiding such things as premature separation of emulsion, development of odors, and bacteria propagation.

By the same token, care of the emulsion while in service is similarly desirable. Extraneous contaminants of every sort should be avoided. Dirt, chemicals, food particles, oil, grease, etc., must not be allowed to get into the emulsion if best results are desired. Chips, grinding grits and dirt formed in the metal working operation and carried into the coolant system should be removed regularly with suitable settling tanks, filters, and strainers to avoid their effects on the emulsion stability.

Germicides may be introduced in several ways in the coolant to minimize and control possible bacteria growth. Many good soluble oils and compounds already contain them so no additions are required to the emulsion. Where they are not so introduced, some operators add a germicidal solution of the water soluble type directly to the emulsion. Bacteria or germs may enter the coolant system in the water, particularly if it is hard water of the kind containing mineral sulfur bearing compounds, or through contamination by contact with a workman having an infection on hands or arms.

Keeping the coolant and coolant system clean, maintaining ordinary sanitary precautions among workers, and use of a good germicide in the system will usually minimize to the point of non-existence, so-called cases of industrial dermatitis, Shell engineers have observed.

Industry practice varies regarding the length of time a coolant is kept in service in a given system. This time may vary from one week to six months depending on production on the machine, maintenance of cleanliness, shutdown practice, temperature control of coolant, and control of emulsion concentration. Obviously, a high

rate of production accelerates the extent of contamination of the emulsion from chips, grits, dust, dirt, etc. Continuous operation, however, serves the useful purpose of continual aeration of the emulsion. Where machines are shutdown over a week-end, particularly in the summertime, a scum layer forms over the surface of the stagnant emulsion. This condition in warm weather is conducive to bacteria growth, if present, odor development, and general deterioration of the emulsion. It can be combatted by maintenance of cleanliness, suitable germicides and in other ways.

Cooling of the emulsion is not only useful in extending its service life but has also proven by tests to result in better machining finish, production and tool life. An optimum temperature range for emulsions used in machining has been found to be from 55-70°F. Cooling can be accomplished by use of fins and air passages, fan drafts, cooling coils and water jackets, or by mechanical refrigeration.

Another control for better service of emulsion coolants, which is sometimes overlooked or not given the full attention it deserves, is control of the emulsion concentration. Every emulsion in use as a coolant for metal working is undergoing a continual change in relative composition.

In some heavy duty cutting operations, the heat generated at the tool point may evaporate the water off at a rate faster than the carryoff rate of oil on the machined pieces. If allowed to progress, this change would result in such a high ratio of oil to water that an inverted emulsion could form, causing loss of all the coolant in the system and necessitating the further loss of down time on the machine for system cleaning and change of coolant.

In grinding operations the rate of oil carryoff is usually such that the emulsion concentration becomes increasingly leaner with service. The change may progress to a point where rusting and emulsion instability occur.

Since emulsions, as coolants, are usually prepared in the proper recommended concentration for given applications, it obviously is insufficient to merely add water or soluble oil or compound by rule of thumb to an operating system. It is wasteful of material and of potential production possibilities.

The wire drawing industry recognizes the importance of proper concentration control, since results, particularly on fine wire, are so dependent on such control. Fundamentally, all the control methods used in metal working industry are based on two procedure steps. First, a sample of emulsion from the operating system is "broken," i.e. soap, fat, oil, pigment, etc., are separated from the water by addition to the sample of a suitable acid or salt. The proportion of "solids" to the volume of the whole sample is a measure of the concentration. Second, a calculation is made of the required amount of soluble oil, compound, or water it is necessary to add to the emulsion to restore the original recommended concentration.

The first step above may be made using some sort of graduated flask; an ordinary 100 cc. measuring flask, a Babcock flask, or a Mighill flask can be used. Usually 5-10 cc. of sulfuric or hydrochloric acid, or some acid salt such as potassium bisulphate crystals may be used as the "breaking" agent. Concentrated sulfuric acid is the most efficient agent although extreme care must be exercised to avoid spilling or splashing on the clothes or person. Painful, dangerous injury or damage to clothes can result from inexperienced use of sulfuric. Dilute hydrochloric is efficient, but a little slower in action. Potassium bisulphate crystals (about a teaspoonful added to 100 cc. of emulsion) appear to be entirely adequate and are easy and relatively safe to handle.

Having measured the concentration of the sample by observing the volume of oil, soap, fat, etc., which has risen in the neck of the flask to the surface of the water, the next step is determination of necessary addition of components to the system. This can be done, of course, arithmetically on paper. However, a new circular slide rule type calculation is now available to industry which simplifies the procedure and prevents errors. It can be used by any intelligent shop man or machine operator, and requires practically no instruction. Full instructions, however, are furnished with the calculator. This calculator may be obtained without charge from any industrial representative of the Shell Oil Company. Two sets of scales are provided on the calculator. One for determining enrichment, and one for dilution of the emulsion being checked.

In considering the application of coolants in specific metal working operations, it will probably be desirable to first regard the old question of emulsion coolants versus oil type fluids. Both have a proper place in metal working applications. In some cases, there may be a choice of either with comparable results, dependent upon their respective compositions. In such cases, the rule of economy will probably influence the decision. Shell engineers believe the principal factors to consider in choosing emulsions or coolants versus mineral type fluids are as follows:

1. Cooling requirement of work and machine
2. Lubrication requirement at point of application
3. Necessary stability and service life
4. Operation requirements regarding:
   a. Finish on work piece
   b. Production rate
   c. Tool or die life
5. Effects of coolant or fluid on working parts or mechanism of machines
6. Physiological effects on operators
7. Operator preference
8. Economy regarding:
   a. Initial costs
   b. Operating costs
   c. Maintenance
   d. Recovery and reuse

A review of these factors will, in any given case, clarify the logical choice of coolant or metal working fluid best suited for the job. Each of these factors with the possible exception of economical considerations will be a function of the particular application and must be weighted accordingly. As mentioned in an earlier part of this article, the principal groups of metal working applications in which coolants, principally emulsion, play any important part are as follows:

1. Metal Cutting and Sawing
2. Metal Grinding
3. Metal Rolling
4. Metal Drawing, Stamping and Forming

The application of coolants in these fields will be considered in this order.

Metal cutting generally implies certain basic requirements of the cutting fluid or coolant. It must possess:

1. Cutting ability with respect to:
   a. Rate of metal removal
   b. Surface finish on work
   c. Tool life

These characteristics are imparted to the fluid by virtue of its:

1. Cooling characteristics
2. Lubricating characteristics
3. Chemical activity characteristics

Emulsion type coolants or fluids, of course, possess superior cooling properties due to the water present which carries off heat rapidly. They may possess considerable lubricating value if compounded with sufficient proportion of such materials as fatty oil, acids, and mineral oils. In general, however, they do not have the lubricating value of mineral type fluids.

Chemical activity can be imparted to emulsions by addition of chemically active agents incorporating sulfur, chlorine, phosphorus, and other compounds. However, care must be taken in such formulations to avoid secondary products as a result of combinations with the water contained in the emulsion. The presence of active chlorine in water, for example, may produce hydrochloric acid resulting in machine and work corrosion, and undesired physiological effects on operators.

In addition, there are other operating requirements imposed on coolants used for metal cutting. They must generally do the following satisfactorily:

1. Have good emulsion stability with water of various types and hardness
2. Settle chips readily in the system
3. Resist rancidity, odor development, bacteria growth, and deterioration
4. Resist foaming in circulatory service
5. Prevent formation of rust or corrosion on work pieces or machine tools

Emulsion stability, deterioration, odor and contamination have already been discussed and will not be expanded on here. Foaming can be prevented by either or both of the following—mechanical arrangement of circulation system to avoid excessive splashing of coolant, and use of foam depressants in the fluid. Severe rusting can be prevented by proper formulation of soluble oil bases and inclusion of rust preventive additions. These methods of product improvement are known to reliable manufacturers and are utilized to furnish superior soluble products to the industry.

There are two broad classifications of soluble oils used in metal cutting, conventional and heavy duty. The former are used in emulsion form as coolants for such operations as drilling, milling, turning, and sawing. The latter, the heavy duty types, contain in addition to conventional emulsifiers plus oil, such components are oils, fatty acids, special compounded mineral oils, chemically active additives and other agents. They are suitable for difficult machining operations ordinarily requiring active type mineral cutting oils, but wherein superior cooling action is required in addition. Such applications may be broaching, heavy boring, hobbing, and heavy duty turning and forming. For these jobs six to ten parts of water are used per part of soluble oil.

Both conventional and heavy duty soluble oils may contain foam depressants, rust preventives, germicides, water softening agents, and other additives to improve their performance. Emulsion coolants are not generally recommended for use in automatic screw machines or similar machines. Leakage of the emulsion into spindle bearings due to ineffective bearing seals may result in displacement of the spindle lubricant and subsequent seizure and damage to spindles.

Paste type compounds are not used to the same extent as soluble oils in metal cutting coolants, although they are used in grinding.

Metal grinding is a special type of metal cutting, the intricacies and problems of which are known to some extent by every tool and lubrication engineer in industry. No attempt will be made here to analyze grinding theories but rather to discuss only the use of coolants in grinding. Practically all cylindrical, centerless, and surface grinding of machined pieces is done with water solutions or emulsions as a coolant. While form and thread grinding employ compounded mineral oils as a cutting fluid and coolant, they represent special cases of application entailing special problems and product characteristics.

The grinding process requires certain properties in the coolant. In addition to those mentioned under the subject of metal cutting, the following should also apply to a grinding fluid. It should:

1. Have suitable wetting out action to insure a continuous film on the work piece.
2. Not have any tendency to form gums or resins in use, nor load up the grinding wheel.
3. Settle chips, dirt, grits, etc., readily in the settling tanks to avoid carry over and scratching of the work piece.
4. Resist rusting tendencies even in very dilute emulsions used in grinding.
5. Not affect the bonding material of the wheel.
6. For some types of work, provide a clear translucent appearance so that work in process may be observed.

To meet these requirements several types of grinding fluids are available. They are:

1. Soluble oils to produce opaque emulsions.
2. Soluble oils to produce translucent emulsions.
3. Grinding paste type compounds.

Any of these may contain wetting out agents, foam depressants, water softening additives or rust preventive compounds. All are mixed with water in proportions from about 40-100 parts water to one part oil or compound, and are used in the emulsion form as the coolant.

The opaque, milky white emulsion is most commonly used in industry. It is generally made up from soluble oil although paste type compounds of the unpigmented variety are also used. Such emulsions, as coolants, are inexpensive, efficient for many kinds of grinding work, and if properly formulated, cope with most problems encountered, such as water condition, ordinary contaminants, mixing problems, and operating requirements both on rough and finish grinding jobs.

Translucent grinding emulsions, prepared from special soluble grinding oils containing a high proportion of emulsifier base, are particularly adapted for use in fine precision finish grinding to close tolerances. Possessing all the normal attributes of a good grinding coolant, they have, in addition, the advantage of permitting the operator to see at all times the point of contact between wheel and work. This is important when the wheel is being brought to the work. With opaque coolants, the operator cannot see through the fluid film. He may, because of this, temporarily shut off the coolant flow causing burning and damage to the work finish.

Although high soap content soluble oils of the type that form translucent emulsions usually cost more than ordinary soluble oils, they actually cost less in emulsion form at the machine. This seeming paradox is explained by the fact that due to their special formulation they may ordinarily be diluted with almost twice as much water for use as conventional oils. The latter are usually mixed with from 20 to 40 parts of water whereas translucent type soluble oils are mixed with from 70 to 100 parts water. Their operating superiority for precision

grinding also makes for economy in better production and finish, and fewer rejects. They combine the transparency and low surface tension of cheap sal soda solutions with the good rust preventive, non-foaming character of modern soluble oils. They do not attack resinoid or shellac bonded wheels as is known to occur with sal soda solutions. The latter may also affect paint on machines and contribute to operator skin and eye ailments if in too strong solution.

Paste type compounds are used to some extent in preparing coolants for grinding. These should be of a high soap type for best results. They may contain some fatty oils which impart lubricating film properties. However, an excess of fatty oils in the emulsion may contribute to loading up of the grinding wheel and gumming of the system. Also chip settling may be affected by too high a fatty oil content. The paste type compounds are usually mixed with several parts of water, preferably hot, and agitated thoroughly to produce a heavy slurry which is then diluted with 70-150 parts of water for use as a grinding coolant. Since soluble oils are much more easily mixed for service, many operators prefer them to the compounds, although, as stated, the latter are also used with good results.

Metal rolling is the third class of metal working operations wherein coolants are employed. This is a broad subject, so for brevity, only a few comments will be made here. Water, water solutions and emulsions are used widely as coolants in rolling of both ferrous and non ferrous metals.

Hot steel ingots and blooms are rolled in mills wherein the rolls are cooled by water spray. Cold reduction of continuous steel strip in tandem mills is accomplished by using either the single or dual system for coolant distribution. With the single system, an emulsion of soluble oil, palm oil, and water is applied by nozzle spray application to the rolls and strip and recirculated for continuous use. Usually the emulsion contains about 1 part soluble oil to 20 or 30 parts water and a small percentage of palm oil. The emulsion temperature is usually maintained at about 150° F to prevent separation in service. Although mineral oil and other types of oil have been tried and are used, the majority of steel rolling has been done with palm oil solutions.

With the dual system, mineral oil or palm oil is sprayed on the steel strip for lubrication, and water in large quantities is sprayed on the work and back up rolls for cooling. Sometimes the oils are applied neat as purchased. In other cases they are mixed about equally with water before application. A part of the oil is salvaged for reuse in the dual system, but most of it is lost down the drain with the cooling water. There are a great many factors to consider in the application of rolling fluids and mill coolants, such as friction characteristics, strip finish, percent reduction, rolling speeds, mill sizes and type, power considerations, etc. Unfortunately, this paper cannot, for space reasons, treat of these subjects here.

In aluminum rolling, hot reduction of ingots is accomplished usually with an emulsion type coolant. This emulsion may be a soluble oil of the opaque kind mixed with 20 to 30 parts of water and sprayed on the work rolls for cooling. Since aluminum is critical to Ph values beyond a narrow range either side of the neutral value, and is subject to water stains, emulsion type coolants are not satisfactory for cold reduction of finished strip. Generally, a light viscosity compound mineral oil is employed in this operation as a strip lubricant and roll coolant.

In copper and brass rolling, compounded mineral oils are also used for most alloys and finishes. These oils are sprayed through nozzles onto the work strip, although water is used for roll coolant. Various viscosities and types and degree of compounding are employed dependent upon the specific job requirements.

Soluble oil emulsions are utilized for some brass rolling, however, particularly where a bright finish is desired. Obviously, emulsions do not have the lubricating value of componded mineral oils. Hence they tend to produce this bright, burnished finish. They offer the advantage of low cost versus mineral oils, which is also a factor to some extent in their use. Such emulsions are the conventional opaque type. They are usually made by mixing 20 to 30 parts of water with one part of soluble oil. The concentration adopted, as in the case of all rolling applications, is determined by consideration of roll slippage versus sheet finish desired.

The application of coolants in metal drawing in the fourth and last subject this paper proposes to discuss.

The use of paste type compounds is traditional in this industry, although soluble oil emulsions and mineral type compounded oils are finding increasing favor in many new applications.

The manner in which drawing compounds are prepared for use and applied depends largely on the type of drawing to be done. The most important factors in selection of suitable compond are as follows:

1. Type of metal to be drawn—ferrous, non-ferrous, and physical proportions of metal.
2. Nature of drawing operation—and severity of draw, percent reduction, work shape, and annealing practice between draws.
3. Coolant or compound application method. These methods are usually:
   a. Circulation of coolant.
   b. Dip in bath of coolant.
   c. Spray application.
   d. Swab application.

The drawing compound, emulsion, or coolant serves in drawing operations to cool and lubricate dies and work thus minimizing die wear, and imparting proper finish to drawn work by eliminating metal pickup or welding, scratches, and tears or fractures. With suitable compounds, frictional heat from drawing is reduced, thus preventing excessive thermal expansion of dies, mandrels, punches, and work. Such expansion, if not controlled, may result in off-size work and shortened service life of the die set-up.

There are three major groups of drawing operations which are employed in drawing of all types of metals, both ferrous and non-ferrous. These are:

1. Wire Drawing.
2. Tube and Bar Drawing.
3. Press Drawing, Stamping, and Blanking.

Wire drawing is done on either bench type machines, generally used for rod breakdown and heavy wire draws, or one of several prominently used high speed enclosed multi-die machines. The latter are used for intermediate and fine wire drawing, both ferrous and non-ferrous. Circulation of coolant prepared from componds is general practice in the so-called wet-wire method. For steel wire a soap fat concentration of ⅓% in the coolant is maintained. Temperature of the coolant is held at 100-150° F. For copper and copper alloy heavy wire and rod breakdown, soap fat concentration of 3-6% are used in coolant at 140-160° F. For fine copper wire drawing (sizes below B. & S. Gauge No. 36) a much more dilute coolant made from a high soap content compound is preferable. Soap-fat concentration is main-

tained at ½% with coolant bulk temperature at about 90-110° F. If too much fat or too rich an emulsion is tried on high speed fine wire machines, sticky black deposits form on the wire at the dies causing wire breakage. However, if soap content is allowed to become excessive, foaming may result. Experience has indicated the proper balance in proportion of these components and correct dilution for optimum results.

Drawing of aluminum wire, coming increasingly into prominence, requires a compound type mineral oil circulated through the dies at a bulk oil temperature preferably under 150° F. The viscosity of oil used is based on severity of draw and size wire, heavier oils for heavy wire, light oils for fine wire.

Tubes and bars of all types of metal are drawn on draw benches operated either mechanically by a chain pull, or hydraulically. It is customary practice to dip tubes in a heavy emulsion of drawing compound and allowing the coating to dry to a certain extent before drawing. Sometimes steel tubes are coated with lime to facilitate drawing. Concentration of soap-fat in the emulsion is held between 15-25% and temperature of dip bath maintained at from 120-160° F. Copper and brass tubes for drawing follow a similar procedure, but are never lime coated. Sometimes an oil is circulated over the die. Steel bars are usually pre-coated with lime and drawn through a die over which mineral or fatty oil blends are circulated. Aluminum tube drawing requires circulation of an oil over the die and through the mandrel. In some cases water soluble oils are applied straight which permits subsequent cleaning with water and eliminates the need for solvent type cleaners used in connection with mineral oils. For heavy draws of both ferrous and non-ferrous tubes, pigmented compounds may be used to furnish the benefits of solid lubrication and avoid metal pick-up, scratches on tube, and premature die failure. Heavily pigmented products are never used in circulation systems, however, since the pigment settles out and would clog horizontal pipe lines in the system.

Press drawing, stamping, and blanking operations usually entail the spray or swab application of an emulsion containing from 15-30% soap-fat or solids. Both pigmented and non-pigmented compounds are used dependent upon severity of draw and subsequent cleaning procedure used. Aluminum drawing compounds contain a high free, fatty acid content, as alkaline solutions attack the aluminum surface. The fatty acid imparts good wetting out characteristics to the emulsion which are desirable since aluminum is very prone to weld on dies and produce pick-up.

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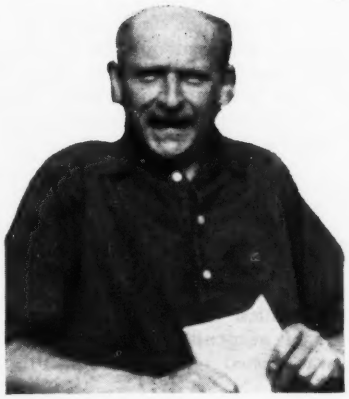
Fats and Oils for Grinding and Polishing*

By E. W. STEINITZ

C. R. Laboratories, Ltd., Consulting Chemists



Dr. E. W. Steinitz was born in Berlin in 1889 and graduated from the Technische Hochschule in 1914, with a degree of "Diplom Ingenieur." Following World War No. 1, he was employed by Daimler-Benz as draftsman and test engineer, later joining the Vacuum Oil Company in their Hamburg branch, as a lubrication engineer.

Dr. Steinitz has published two text books on Lubrication, and since 1938 has been in England as a consulting engineer. He has many patents to his credit.

A GREAT many substances are in use as suspending media for abrasives including diamond, others are being suggested practically every day[1]. Since, for various reasons, oils and fats of either animal or vegetable origin appear to be preferred[2], in this article are compiled the main characteristics of such products, which are in common use in various trades. It is hoped that this will encourage further investigations into this problem.

In the following it is proposed to discuss, in more detail, those oils which we believe may be most useful in the preparation of efficient suspensions and pastes. Furthermore, the chief properties and methods of preparation of these oils and fats are compiled as short notes, and in each case it is stated whether the particular substance has already been employed as suspension in connection with diamond abrasives. In Table I reference is made to certain oils which are not yet known to be suitable carriers of abrasives.

It will be noticed that we have given the viscosity, which is a very important property, in degrees Engler. This system is quite uncommon in this country, but it may be more easily understood by those who are not scientists. The Engler viscosity is simply the fluidity of the liquid with water as the basis of comparison. To take an example, if an oil has an Engler viscosity of 12, it flows 12 times slower than water. The viscosity, of course, has to be given at a definite temperature since all oils change their viscosity with temperature.

[1] British Patent 573,683, 18th May, 1944, A. E. Jones, British Insulated Cables Ltd. Cyclohexanol is used as a carrier for diamond powder in the drilling of diamond dies for wire drawing.

British Patent 574,635, 14th July, 1944, R. W. Lunt, J. A. Burns, G. J. Dean, Callender's Cable & Construction Co. Ltd. Approximately 5 parts by volume of carbon tetrachloride to one part of diamond powder are used as the cutting medium for drilling, enlarging, and polishing diamond dies for wire drawing.

[2] When considering the influence of the oil which surrounds the diamond abrasive grain and, so to speak, binds it temporarily to either lap or grinding body or to the workpiece to be ground, polished or lapped, the influence of the material and the porosity of the lap itself, such as metal, wood or plastic, etc., should not be overlooked.

*Reprinted from *"Industrial Diamond Review,"* issue of November, 1946.

Olive Oil.

Olive oil is made from the flesh and stones of the olive, the fruit of the olive tree. The flesh of the olive contains 40 to 60% oil and the stone from 12 to 15% oil.

The trade differentiates between technical and edible grades of olive oil, the latter being also called Oil of Nice.

In order to make olive oil, the fruit, together with the stones, is first squashed, the pulp obtained in this manner being treated in hydraulic presses which can be heated.

The finest edible oils are obtained by cold pressing, whereas the commercial grades are obtained by heating up the press and increasing the pressure.

Products of still lower grade are obtained from the pressing residues by extraction with sulphur tetrachloride, and these grades contain a large amount of oleic acid.

A good edible olive oil should not contain any acid, whereas the commercial product may contain up to 6% of free acid. It has often been assumed that free acid corrodes metals, but it has been proved that the corrosion due to an organic acid like oleic acid is very slight, if it occurs at all. On the other hand, the content of oleic acid increases the wetting power of the oil, and it is very likely that good suspensions of diamond powder are more easily obtained with oils of high acid content than with others, due to the fact that an oil containing oleic acid wets the diamond particles better than a very pure olive oil of the edible kind. Olive oil is clear and fluid, of straw yellow to dark golden yellow color, frequently with a greenish tint. It has a definite aroma but not a very pronounced taste.

The diamond industry has made extensive use of olive oil for many centuries for preparing diamond abrasive laps and paste. A thin film of oil is spread on the cast-iron grinding and polishing laps before the diamond powder is rubbed into the surface. In addition, a paste of diamond powder in olive oil is applied

in very small quantities during the grinding process. For sawing diamonds, a paste of diamond powder in olive oil is applied by means of a steel roller[3] to the periphery of thin rotating phosphor-bronze blades. Diamond dies for wire drawing are usually drilled with steel needles charged with a diamond-olive oil paste[4]. Olive oil is used in polishing synthetic sapphire bearings for instruments and meters, and in the drilling of ring stones. The polishing lap for sapphire may be of pear, beech, or orange wood soaked in olive oil, the diamond abrasive usually being applied as a paste prepared with olive oil. The drilling needle is of steel, and is also charged with diamond powder in olive oil.

Vaseline (see later) is used for preparing the polishing paste in the Swiss jewel bearing industry, the diamond powder being rolled down to about 1 micron size between steel rollers in a special machine. For this process, one roller is covered with vaseline, and the diamond powder evenly distributed over it. Eventually, the paste is scraped off the rollers and is mixed with olive oil. The diamond paste contains iron, of course, but the solid particles are very fine, and this is more essential in polishing comparatively "soft" materials like sapphire than in working a harder material like diamond which seems to be the least sensitive to coarse particles.

In all cases, when a paste of diamond powder in olive oil is used, it is advisable to let the paste first "soak" for a day or two, and it is quite possible that the improved cutting action after soaking is due to the beneficial effect of a higher content of oleic acid which develops when the oil goes stale.

During the war a great shortage of olive oil developed both in this country and in America, and numerous substitutes were developed and used. In this country use was made of other vegetable oils similar to olive oil in their action, such as rape seed oil and ground nut oil (oil of Arachid), but certain American oil firms are said to have developed substitute mineral oils. Whether these oils will be used after the olive oil shortage has passed, is very questionable.

Rape Seed Oil.

This oil is produced from the seeds of the rape plant and from different varieties of beetroot, turnip, and cabbage. The seeds contain from 33 to 43% oil, manufacture taking place by pressing. The residues or oil cakes obtained after pressing 2 or 3 times still contain from 7 to 10% oil and are used in great quantities all over the world for the feeding of cattle and pigs.

The crude rape seed oil has to be refined by stirring in 1% of sulphuric acid after which the oil is neutralised by lime solution or simply by washing with water.

Commercial rape seed oil contains about 2.1% of oleic acid, but it should be absolutely free from mineral acid. It must not dry when exposed to air and should not yield any sediment during storage. It gains in quality during storage, and a usual requirement is that it be stored at least 3 months before use. A good test for rape seed oil is that it should burn with a pure white flame.

Raw rape seed oil has a characteristic aroma and a rather disagreeable taste; highly refined rape seed oil is of light yellow color. It is used in engineering as a hardening oil. During the war when olive oil was in short supply, rape seed oil was found to be one of the best substitutes for polishing synthetic sapphire bearings. In many instances it was just as good as olive oil for the preparation of diamond abrasive wooden laps or paste. Its application was less successful, however, in the drilling of ring jewels.

Oil of Arachid.

This oil is more commonly known as ground nut oil or pea-nut oil, and its main use in many parts of the Far East and West Africa is for food. The kernels of the nut contain 30 to 50% oil, the hulls about 4% oil, the oil being obtained by pressing the nuts once in the cold and twice in the hot. The finest oils, those from the first pressing, are used only for food, and the best oil is colorless and nearly tasteless. The oils from the second and third pressings are yellow. Ground nut oil is very viscous at temperatures between 10 and 20 deg. C. and it solidifies at 3 deg. C.

Castor Oil.

This oil is obtained from the seeds of a plant called *ricinus communis,* but why it is called castor oil is not generally known. *Castor* is the zoological name for the beaver, and the beaver produces a certain oil in one of its glands, which has been used for the treatment of all kinds of ailments. Subsequently, the name of castor oil was passed on to the substitute, the oil of *ricinus communis.*

The oil is obtained by heating the seeds to 80 deg. C., and then pressing. Only the oils obtained from the first pressing are of good quality, the second and third pressings are used for the manufacture of sulphonated castor oil or Turkey Red oil. The extraction of castor oil can only be done with carbon tetrachloride or alcohol, as the oil is not soluble in white spirit or naphtha.

A good castor oil should be colorless, and the specific gravity should be 0.959 to 0.968 at 60 deg. F. It should be completely soluble in 90% alcohol and contain not more than 1.5% of oleic acid. It should be free from resin, resin oil and cotton seed oil. Its freezing point is about 18 deg. C.

It must be remembered that ordinary castor oil is not miscible with mineral oil, but a soluble form of castor oil can be obtained by polymerisation. This is done by distilling from 5 to 10% of the oil at 300 deg. C., and refining the residue according to requirements.

Castor oil can also be made water-soluble by transforming it into what is known as Turkey Red oil. This is obtained by treating castor oil with concentrated sulphuric acid and subsequent neutralisation. Other Turkey Red oils are obtained by the sulphonation of olive oil, rape seed oil and fish oil. With the aid of good Turkey Red oil, mixtures and emulsions can be obtained which contain at the same time mineral oils, turpentine, water, and different hydrocarbons.

Castor oil was successfully used during the war as a substitute for olive oil, and in the sawing of diamond it may be successfully used owing to its high power of sticking to metals (phosphor bronze). It may be mentioned that castor oil was already usefully applied during World War I as a lubricant for aero-engine bearings. There seems to be no apparent relationship between the industrial and the medicinal uses of this oil.

Vaseline or Petroleum Jelly.

Petroleum Jelly is the residue obtained from the distillation of preferably, paraffinic petroleum (crude oil), after the lighter distillates like petrol, paraffin oil (kerosene) and lubricating oils have been driven off. After slight refining, petroleum jelly is obtained in the

[3] P. Grodzinski, *Diamond and Gem Stone Industrial Production,* London, 1942, p. 47.

[4] Diamond dust, a review of recent literature, *Industrial Diamond Review,* Vol. 5, 1945, pp. 169-171, 181.

TABLE 1—PROPERTIES OF OILS, FATS AND GREASES (According to Holde)

Kind of Oil[1]	*Consistency at Room Temperature*	*Index of Refraction at 20 deg. C.*	*Specific Gravity at 15 deg. C.*	*Solidification Point deg. C.*
Olive oil, from the flesh of olives Olivenoel or Baumoel Huile d'olive	Engler viscosity at 20 deg. C. 11 to 13	1.467 to 1.471 61.7 to 68 scale divisions	0.9140 to 0.9190, less valuable 0.9200 to 0.9290	Some still liquid at –5, solid at –9; others solid at 0 deg.
Olive kernel oil Olivenkernoel Huile de noyeau d'olive		25 deg. 1.4682 to 1.4688	0.918 to 0.920	
Peanut (arachis) oil Erdnussoel Huile d'arachide	Engler viscosity at 20 deg. C. 10 to 12	1.468 to 1.472 63.2 to 69.5 scale divisions	0.9163 to 0.9200	Generally solid at 0 deg.
Lycopodium fat Baerlappoel		1.467	0.936	
Japanese tea oil Teesaatoel		1.468 to 1.471	0.916 to 0.917	–12 to –15
Castor oil Rizinusoel Huile de ricin	Engler viscosity at 20 deg. C. 139 to 140	1.477 to 1.478 77.5 to79.4 scale divisions	0.9613 to 0.9736	–10 to –18
Rape seed oil Rapsoel			0.9110 to 0.9175	
Almond oil Mandeloel		1.4728 15.5 deg.	0.9160 to 0.9200	–10 to –21.5
Cocoanut oil Kokosnussoel Beurre de coco		60 deg.—1.441 40 deg. 33.5 to 36.3 scale divisions	0.9250 to 0.9383	Becomes solid 14 to 32.1, melts 20.3 to 28.
Palm oil, from fleshy part of fruit Palmoel Huile de palme	Solid.	60 deg. 1.451 40 deg. 47 scale divisions	0.9120 to 0.948	Melts according to age and source from 27 to 52.5.
Palm nut oil Palmkernoel Huile de palmiste	Solid.	60 deg.—1.4431 40 deg. 36 to 36.5 scale divisions	0.9410 to 0.9520	Melts between 23 and 28.
Vegetable tallow, from seeds of Stilingia sebifera Chin. Talg Suif vegetale de Chine		scale divisions at 50 deg. 38	0.915 to 0.922	Trade samples 24 to 29 extracted with solvents 34.
Cocoa butter Kakoabutter Beurre de Cacao		60 deg. 1.4220	0.950 to 0.995	23 to 26, melts between 30 to 33.
Japan wax Japanwachs Cire du Japon			0.970 to 0.980	48.5 to 53.
Neat's-foot oil, bone fat Klauenfette, Knochenoele Huile de pieds de boeuf, suif d'os	Engler viscosity at 20 deg. C.—12.0. Oils rich in stearin, often solid.	20 deg. 1.66 to 1.470, 60 to 66 scale divisions	0.914 to 0.916	According to the method of preparation, above or below 0.
Horse fat Pferdefett Graisse de cheval	Considerable separation of stearin or entirely solid.	40 deg. 53.7 scale divisions	0.919 to 0.9220	Variable, according to Amthor and Zink, between 20 and 30, melting point 30 to 33.
Beef tallow Rindstalg Suif de boeuf	Solid.	60 deg.—1.4510 40 deg.—44 to 49 scale divisions	0.943 to 0.952 100 deg. 0.860 to 0.861	Melting point 42.5 to 46.
Mutton tallow Hammeltalg Suif de moulon	Solid.	60 deg.—1.4510 40 deg. 44 scale divisions	0.937 to 0.940 100 deg. 0.857 to 0.860	Melting point 46.5 to 51, solidification point 32.9 to 41.0.
Tallow oil Talgoel	Liquid to semi-solid.		100 deg. 0.794	34.5 to 37.5.
Lard Schweinschmalz Sain-doux-Lard	Salve-like.	40 deg. 49.0 to 52, (45) scale divisions	0.931 to 0.938 100 deg. 0.858 to 0.860	27.1 to 29.9; melting point 33 to 48; generally 36 to 40.
Lard oil Schmalzoel Huile de Lard	Liquid to semi-solid.	40 deg. 41 scale divisions	0.915	10.
Butter fat Butterfett Beurre de vache	Salve-like.	40 deg.—41.6 to 44.2 (46) Margarines 58.6 to 66.4 scale divisions	0.936 to 0.946 100 deg. 0.864 to 0.868	19 to 20, melts at 29.5 to 34.7.

[1] Names of oils in English, German and French.

form of a dark yellow to light green grease. After further refining, medicinal vaseline, which is either white or light yellow, is the end product.

Pure vaseline has a melting point of 42 deg. C. to 45 deg. C. and can, of course, be heated and solidified again without any change in its constitution. In this respect it is preferable to all other fats and waxes. Genuine vaseline can only be obtained from Pennsylvania petroleum or crude oil, these being the only ones that give a residue that will not crystallise.

The waxes contained in all other crudes are sold under the name of paraffins and are hard and brittle, showing a coarse crystalline texture. So-called "artificial vaselines" are mixtures of light mineral oil and paraffin wax, but they have the disadvantage that after heating and solidifying again, the paraffin crystllises out and the oil separates.

Vaseline mixed with olive oil is used in the preparation of "rolled" diamond paste for polishing synthetic sapphire bearings as already mentioned. Vaseline may also be used as a carrier for diamond dust in drilling synthetic sapphire ring bearings.

Lanoline.

Lanoline is refined wool fat obtained in the form of a dark brown wax by washing sheep's wool. This is refined by removing the acids and soaps, and it is then sold in the form of light yellow cream. Lanoline is a complicated mixture of different components and can be described as something between a wax and a fat. It can easily be emulsified and saponified, so that products of differing consistency can be obtained by the addition of varying amounts of water. In addition, these emulsions are very stable.

The melting point of pure lanoline is between 38 deg. C. and 45 deg. C., but by the addition of a little water the melting point can be lowered to about 30 deg. C. After being liquefied by heat, it solidifies again on cooling and regains its original consistency.

Cocoa Butter.

This vegetable product has lately been tried for abrasive suspensions and the tests are quite promising because the material is solid up to 26 deg. C. or even 30 deg. C., and after melting solidifies again without changing its properties. Fats like ordinary butter, as is well known, change their properties very markedly on re-solidification.

It may be suggested that palm oil, lard, vegetable tallow or chinese tallow, and japan wax also be tested, as their properties are very much like those of cocoa butter.

Mustard Oil.

This is obtained from the seeds of either the black or white mustard plant. Black mustard contains from 15 to 20%, and white mustard from 25 to 35% of oil. The oil is extracted by crushing and pressing the seeds. The pressing residues are further treated for essential mustard oil, but this is not used for lubricating purposes. The oil contains about 2% oleic acid and a certain sulphur content is commonly found to be present.

About 30 years ago mustard oil was suggested for the lubrication of the under-water bearings of water turbines and similar machinery, the reason given being that it is not easily washed away by water. No information on the use of this oil in connection with diamond and other gem stones has so far been forthcoming.

Cotton Seed Oil.[5]

This is obtained from the seeds of the cotton plant. The kernels after being separated from the cotton wool and the husks, are then crushed, heated and pressed. The crude oil which is dark-brown or red in color, is cleaned with a 10 to 15% solution of caustic soda, all the pigments and slimes being saponified in the process and forming what is called the soap stock. The oil is then bleached with Fullers Earth to yield the edible oil which is used for margarine and cooking fat manufacture. The oil is of low viscosity and solidifies at about the freezing point of water. Cotton seed oil is semi-drying, that is to say, it changes quickly when applied in a thin coating and exposed to air.

Linseed Oil.[5]

Linseed oil is the best known representative of the drying oils. If exposed to air it quickly changes all its properties by oxidation and polymerisation, and in thin coatings soon dries hard. The requirements of a good linseed oil are that it should be stored for at least several months before delivery and should yield no sediment in storage. If exposed to air and light in a thin film or glass or china, it should form after 5 days at 20 deg. C. an absolutely dry coat which should not be sticky. It is of very low viscosity and it is very frost-proof, solidifying at 50 deg. to 30 deg. C.

Linseed oil can be boiled in the presence of lead compounds or manganic hydroxide by which process the drying properties are greatly enhanced. Boiled linseed oil, if applied in a thin coating on glass, should not be sticky after 24 to 48 hours.

Quick drying oils will not as a rule be applicable for carrying diamond dust because they change their properties too quickly even when not applied in thin layers.

Hemp Oil.[5]

The properties of hemp oil are very similar to those of linseed oil, but hemp oil is not generally available in a pure state. It is very quick drying.

Chinese Wood Oil.[5]

This oil is sometimes called tung oil. It is a quick drying oil of high viscosity. Freshly made wood oil solidifies at 2 deg. C. to 3 deg. C., but old oil is very much more viscous and very frost-proof. Solidification takes place at 18 deg. to 21 deg. C.

Bone Oils.[5]

The best known of these oils is calves foot oil. It is made by boiling calves feet, followed by extraction of the oil with solvents. Calves foot oil has very good ageing properties in that it remains unchanged even when exposed to air and light for a long time. At the same time, its lubricating properties are very good, and it has been used for centuries in the lubrication of clocks, watches, and other fine machinery and instruments. Only during recent years have better oils for these purposes been found. The normal solidification of calves foot oil takes place at 10 deg. C., but with special treatment, far lower solidification temperatures can be obtained.

Oils from Sea Animals.[5]

As will be seen from the table, a considerable num-

[5] The application of the oils as suspending media for diamond abrasives is not yet known, but some notes on these oils and their different characteristics may be of use.

ber of oils are obtained from sea animals. Of these, seal oil was long used for lubricating purposes, but it has now been discarded. Whale oil has many properties which make it suitable for the purpose of taking up diamond dust, because it has very good wetting properties and it is readily available at all times. The fishy smell can now be overcome by modern manufacturing methods. Another oil which is worth trying is cod liver oil which is of very low viscosity and very frost proof, solidifying at 10 deg. Another oil which has interesting properties is porpoise oil. If of good quality, that is to say made from parts of the head and the jaw of the porpoise, it is very frost-proof and of high viscosity.

Oleic Acid.[5]

This is sometimes called oleine or linol acid. Oleic acid is not strictly speaking, a vegetable or animal oil, but is obtained from linseed oil by separating the liquid fatty acids from the stearine. They are very viscous and may be of interest in the present problem because they are easily emulsified or saponified and are then miscible with water when products of any desired viscosity up to the highest can be obtained.

Conclusions.

Practical tests should, of course, embrace a wide variety of applications, since conditions like temperature and working pressure are bound to influence the properties of the oil or fat; different grain-sizes of diamond powder may also require different carrying media for optimum results, especially as stress is generally laid on stock removal for the coarser grain sizes and on surface finish for the finer grain sizes.

In this article only those fats and oils are mentioned, which might serve as media for the abrasive during actual operations. Practically any oil or grease, however, is suitable for holding the abrasive powder for the short times, during which the tool is being prepared. In notched copper saw blades for instance (for sawing synthetic sapphire, etc.) which are charged with diamond dust before the notches are closed, machine oil is good enough for holding the diamond dust until it is fixed in position by mechanical means. Afterwards the saw may be annealed and the oil destroyed. During the sawing process water serves as the lubricant and coolant.

This article has not dealt with lubricants and coolants for diamond grinding wheels where diamond grains are bonded in metal or non-metallic bodies, nor with wheels into which diamond dust is pressed, rolled or hammered in.

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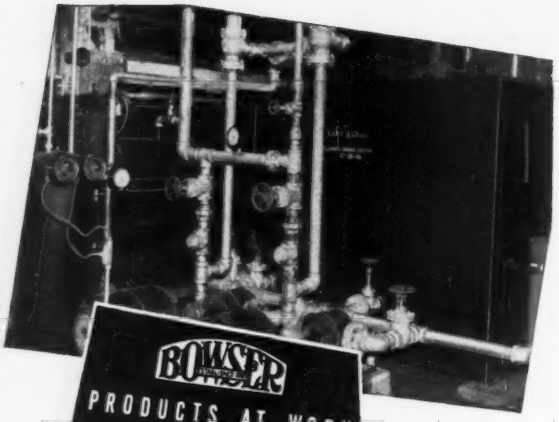

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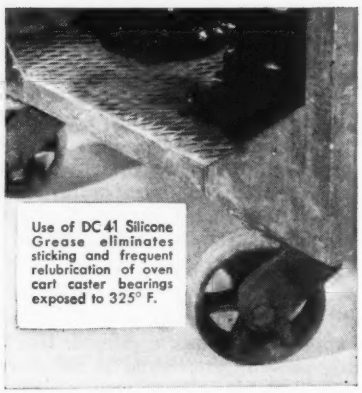

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3 IMPORTANT — DAYS —

April 19, 20, 21, 1948

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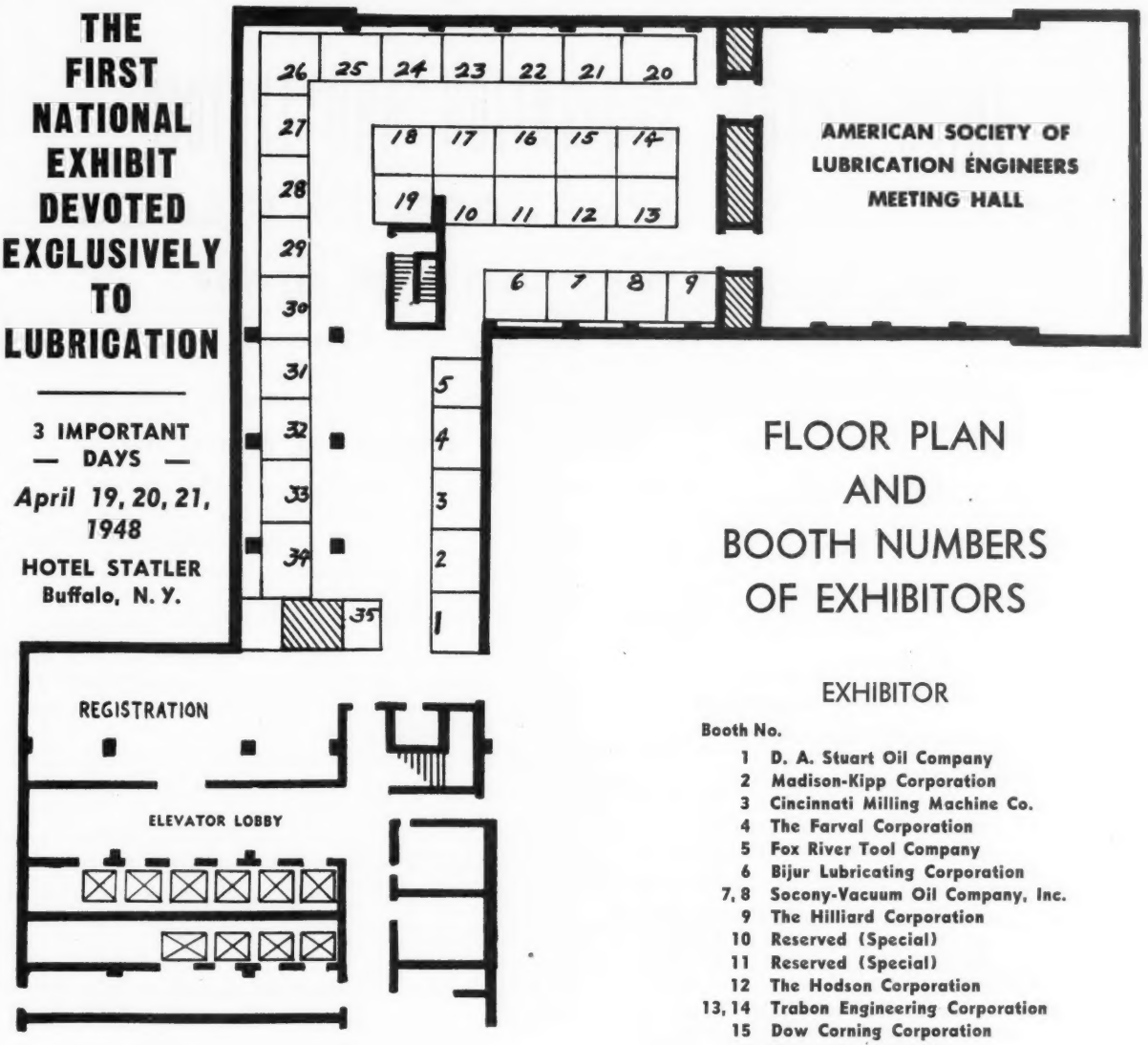

FLOOR PLAN AND BOOTH NUMBERS OF EXHIBITORS

For the first time in the history of our Society we are bringing together the products of key manufacturers of lubricants and lubrication devices to be shown to the key men in the lubrication division of Industry assembled for the Convention.

Booth No.	EXHIBITOR
1	D. A. Stuart Oil Company
2	Madison-Kipp Corporation
3	Cincinnati Milling Machine Co.
4	The Farval Corporation
5	Fox River Tool Company
6	Bijur Lubricating Corporation
7, 8	Socony-Vacuum Oil Company, Inc.
9	The Hilliard Corporation
10	Reserved (Special)
11	Reserved (Special)
12	The Hodson Corporation
13, 14	Trabon Engineering Corporation
15	Dow Corning Corporation
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17	The C. B. Dolge Company
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20	E. F. Houghton & Company
21	Bowen Products Corporation
22	Freedom-Valvoline Oil Company
23	C. A. Norgren Company
24, 25	Shell Oil Company, Inc.
26	Gray Company, Inc.
27	Tide Water Associated Oil Co.
28, 29	Stewart-Warner Corporation
30	Air-Maze Corporation
31	Swan-Finch Oil Corporation
32	Gits Bros. Mfg. Company
33	Bowser, Inc.
34	Lincoln Engineering Company
35	Lubrication Engineering

P R O G R A M

THIRD ANNUAL CONVENTION AND EXHIBIT

THE AMERICAN SOCIETY OF LUBRICATION ENGINEERS

Mon., Tues., and Wed.,---April 19, 20, 21, 1948

HOTEL STATLER — BUFFALO, NEW YORK

MONDAY, APRIL 19, 1948

9:00 A. M. REGISTRATION — 17th Floor Hotel Statler

Official Opening of Exhibits

9:30 A. M. BUSINESS MEETING OF OFFICERS AND DIRECTORS

11:00 A. M. GENERAL SOCIETY BUSINESS MEETING

Chairman — K. E. McHenry

"President's Message" — O. L. Maag

12:30 P. M. WELCOME LUNCHEON — Niagara Room.

Chairman — W. G. Peuchen

Welcome to Buffalo by the Honorable Bernard J. Dowd, Mayor of the City of Buffalo. Speaker to be announced.

2:15 P. M. OPENING TECHNICAL SESSION — Assembly Room.

Chairman — W. T. Everitt.

"What Management Expects of Lubrication Engineers" — W. H. McKaig, International Business Machine Corp.

"Lubrication Engineering Education"— D. D. Fuller, Columbia University.

"The Tapered Oil Film" — with moving pictures illustrating principles of hydrodynamic lubrication. John Boyd, Westinghouse Elec. Co.

4:30 P. M. EXHIBITS.

9:00 P. M. STAG SMOKER.

The Buffalo Section cordially invites all members of the A.S.L.E. and visitors in attendance at the Convention to be its guests. Football pictures, magic, fun and refreshments.

TUESDAY A. M., APRIL 20, 1948

9:30 A. M. TECHNICAL SESSION ON CHEMISTRY AND PHYSICS OF LUBRICATION — Assembly Room.

Chairman — Thomas A. Marshall.

"Mechanism of Action of Bearing Corrosion Inhibitors in Crankcase Lubricants" — C. F. Prutton and J. D. Guttenplan, Case Institute of Technology.

"Corrosion and Wear of Single Metal Crystals" —A. T. Gwathmey, University of Virginia.

"Alumina Filtering Media"—E. M. Kipp, Aluminum Co. of America.

9:30 A. M. TECHNICAL SESSION ON MECHANICAL ENGINEERING IN LUBRICATION Center Wing

Chairman — J. E. Farry.

"Vibration Problems in Bearing Design"— A. C. Haag, Westinghouse Elec. Co.

"New Developments in Bearing Construction"— A. M. Cadman, Cadman Mfg. Company.

"Anti-friction Bearing Developments"— A. W. Murray, S.K.F. Industries, Inc.

12:30 P. M. LUNCHEON — Niagara Room.

Chairman — Edward A. Perkins.

Speaker to be announced.

P R O G R A M

TUESDAY P. M., APRIL 20, 1948

2:15 P. M. CONCURRENT GENERAL TECHNICAL SESSION — Assembly Room.

Chairman — Burton C. Fowler.

"Effects of Cutting Fluids and Power Requirements in Metal Cutting Operations"— A. O. Schmidt and G. V. B. Sirotkin, Kearney & Trecker.

"Performance of Diesel Engine Bearings"— L. M. Tichvinsky, Washington University (St. Louis).

"Evaluation of Oil Filters" — J. I. Clower, University of Delaware.

2:15 P. M. CONCURRENT GENERAL TECHNICAL SESSION — Center Wing.

Chairman — James M. Courtright.

"Textile Spindle Performance Characteristics" — F. S. Jones and S. P. Marley, Socony Vacuum Company.

"Lubrication of Mining Machinery"— J. J. Slomer, Goodman Mfg. Co.

"National Cash Register Company Lubrication Practice" — R. F. McKibben, National Cash Register Co.

7:00 P. M. ANNUAL BANQUET — Ballroom.

Toastmaster — Burgess H. Jennings.

Speaker — To be announced

Introduction of New Officers.

(Dress Informal)

WEDNESDAY, APRIL 21, 1948

9:30 A. M. TECHNICAL SESSION ON MACHINE PRACTICE — Assembly Room.

Chairman — George W. Miller.

"Machine Tool Lubrication from the Builders Point of View" — F. O. Hoagland, Pratt & Whitney.

"Cutting and Grinding Oils" — W. H. Oldacre, D. A. Stuart Oil Co.

(Two or three prepared discussions to supplement this paper.)

9:30 A. M. GENERAL TECHNICAL SESSION — Center Wing.

Chairman — Dr. W. H. Millett.

"Laboratory Evaluation of Synthetic Oils and Greases" — C. M. Murphy and Leon Newman, Naval Research Lab.

"Fundamentals of Cutting Fluid Action" — M. E. Merchant, Cincinnati Milling Machine Co.

"Friction and the Mechanism of Lubrication" — J. J. Bikerman, Merck & Co.

2:15 P. M. TECHNICAL SESSION ON TEST METHODS AND THEIR INTERPRETATION Assembly Room

Chairman — Melville Ehrlich.

"The Significance of Lubrication Oil Tests"— C. E. Hulme, Control Chemist, Kendall Refining Company.

"The Significance of Chemical Tests to Consumers of Lubricants"—William Eisman, Jr., E. F. Houghton & Company.

"Certain Functional Tests for Lubricants and Their Interpretation"— T. G. Roehner and E. S. Carmichael, Socony-Vacuum Company.

4:30 P. M. BUSINESS MEETING OF OFFICERS AND DIRECTORS A.S.L.E.

Plant visitation trips by special arrangement at A.S.L.E. Booth No. 35.

This program has been carefully planned to be of real value to men who design, operate and maintain today's highly complex industrial machinery. The American Society of Lubrication Engineers, its officers, and the Buffalo Convention Committee extend a cordial welcome to all those interested, to attend the technical and social functions listed above.

A nominal registration fee of $2.00 will be charged non-members. This amount may be credited toward dues of guests who make application for membership in the Society within 30 days of the convention.

Convention News

Standing: Tom O'Rourke, Ed Perkins, Fred Sponholz, Norman McCarthy
Seated: Jim Farry, Walter Peuchen

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NATIONAL PROGRAM CHAIRMAN

We are calling particular attention to the National Chairman of our Program Committee, Dr. Henry E. Mahncke of Westinghouse, who is doing an outstanding job in getting together the speakers for the Program, which is outlined on another page in this issue. Dr. Mahncke started this work in July, 1947, and has been very successful in his efforts. A glance at the Program shows the wide range of subjects that will be covered in the three-day session. Something of interest for everyone, and for the first time, he is introducing concurrent sessions held in two different meeting rooms which will offer a wider choice of Programs. This has been a big job and we congratulate Dr. Mahnke on the final outcome of his hard work.

Buffalo Convention Committee

Chairman W. G. Peuchen of the Buffalo Convention Committee announces that plans have been completed for the entertainment and reception of members and guests at the A.S.L.E. National Convention, April 19, 20, and 21, 1948, at the Statler Hotel in Buffalo, New York.

There will be luncheons scheduled for Monday, the 19th, and Tuesday, the 20th, at which interesting talks will be given by prominent Buffalo men. The Honorable Bernard J. Dowd, Mayor of the city of Buffalo, will welcome the guests at the first luncheon.

The Buffalo Section issues a cordial invitation to all members and guests in attendance at the Convention to be their guests at a stag smoker to be held Monday evening at 9:00 P. M., where there will be football moving pictures, fun and plenty of refreshments.

Kenneth E. McHenry and James M. Courtright, Chairman and Co-Chairman respectively of the Buffalo Section, will head the Reception Committee. Norman G. McCarthy and Thomas J. O'Rourke have charge of the arrangements for the stag smoker. James E. Farry has charge of the Convention Program, while Fred C. Sponholz has the pleasant duty of providing entertainment for the ladies in attendance. Arthur E. Mould will look after the transportation provided for members and guests. George Findlay is in charge of the banquet arrangements.

Any members or guests wishing to visit particular industries in Buffalo will find that arrangements may be made for such trips at the registration desk on Monday and Tuesday. These arrangements will be under the management of Harold J. McLaren.

The splendid pre-planning and well-known hospitality of Buffalo, combined with the excellent Program and Exhbits, should make this the outstanding meeting of A.S.L.E. history.

On the Beam...

Cyanamid Chemicals for the Petroleum Industry

AERO* SPECIALTY CATALYSTS for many chemical processes

AEROCAT* SYNTHETIC FLUID CRACKING CATALYSTS
Ground Microspheroidal

AEROLUBE** ADDITIVES...for highest quality Regular, Premium, Heavy-Duty Motor Oils

Consult our technical staff for complete information or assistance in the use of these products to meet your specific needs.

When Performance Counts...Call on Cyanamid

*Trade-mark
**Reg. U. S. Pat. Off.

American Cyanamid Company
Petroleum Chemicals Department
30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.

LUBE SPOTS

In this issue, we bring you excerpts from an article by Warren G. Bailey, partner in McKinsey, Kearney & Company, Chicago, that was published in LUBRICATION ENGINEERING, June, 1945, in which he urges that management adopt measures and techniques required to attain low operation cost through improvement in lubrication practice.

It would be a simple thing here to quote some technical definition of the term "Lubricant," but Webster has said that: "It is a substance which is applied to moving parts in an effort to reduce friction."

This brings many thoughts to me. I can remember in my first factory job how the oiler and the laborer with his grease can, would go from spot to spot, dropping a little oil here and there on the overhead shafting. Or, going from machine to machine, take off a grease cup, fill it and put it back again. There was little or no thought of the real importance of the task, or the elements of the problem of lubrication.

Later there came some advance with the coming of the maintenance man and the maintenance department. Still later, came the more modern maintenance department with its specialists for certain types of maintenance and repairs. Only recently has this developed to a point where we talk now of the plant engineer. Even he is scarce, so far as many of even the fairly large companies are concerned.

It seems to me that there are several things in which the management is interested when the subject of lubrication is considered, especially when we analyze the subject from the standpoint of cost. After all, it is primarily cost which interests Management.

There is the cost of the lubricant, which is a direct cost in its manufacturing accounts. From the standpoint of the direct cost of the lubricant alone, the lower the cost per pound or per gallon, the better Management is satisfied. But a wise Management is not satisfied with giving its attention to direct cost only. It must also be interested in the frequency, with which the lubricant and the cost of the lubrication process has on the asset and on the product, and particularly upon the cost of the product manufactured. It therefore must give consideration to the effect of the lubricant and the frequency of its application on the life of the machine, excessive maintenance costs, the extent of repair costs, and the frequency of shutdowns and breakdowns.

Then there is the question of the performance of the machine. It will operate more smoothly if there is less stress and strain on the machine itself. If there is less wear, the machine may have a very much longer life than contemplated when the depreciation rates were set. On this, the management will make a profit by the saving of depreciation expense, perhaps for one or two, or ten years beyond the life expectancy.

Then there is the question of the number of pieces or parts or products—or even of operations—which the machine will deliver. If there are less shutdowns, less breakdowns, smoother operation, the volume of units may be vastly increased for the same amount of wear, depletion and depreciation of the machine.

The effect of the lubricant on the performance of personnel is also important. Dermatitis and other forms of affliction caused by some lubricants hinder production. Accidents resulting from poor lubrication result in loss of time and extra cost and expense to the company. To the extent that lubricants can avoid these results, cost is reduced and performance is increased. All of these factors must be considered in judging the cost of the lubricant.

These are some of the ways, in which management views the subject of lubrication, and some of the points to which it must give greater and greater attention.

Perhaps we should stop for a moment and give just a little attention to the cost of materials. One of the excessive costs in any highly machined business, is that of materials. Standard allowances are usually made for loss, because of rejections and defective performance by machines and personnel, but in recent years these normal ratios have been far below the actual loss. Some of the reasons for these excessive losses may be attributed to poor engineering, bad tooling and poor timing, and planning of work. Some of it however, is the result of poor performance on the part of machines, because of poor lubrication, excessive breakdown and wear.

The Lubricating Engineer

The Management is interested in the cost of operation, and particularly in the cost of operation as it is affected by the cost of machines in the manufacturing process. All the subjects which have been mentioned, have come to the attention of Management; many companies have spent a great deal of money in an effort to solve most of the questions which may arise, and many have taken steps which would keep costs within reason and the performance of equipment and of personnel up.

To a great extent, industry has depended upon companies selling lubricants to tell them what their lubricants will do, and to assist them in their problems of lubrication, without employing men themselves, who are qualified either to properly maintain their machines and equipment, or to analyze the problems which are so vital in the conservation of fixed assets, or in controlling their depletion in manufacturing operations.

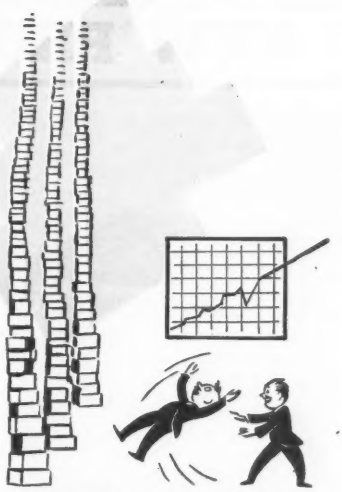
Through the years of experience, and the process of development from the old situation with the oiler and the laborer, to the maintenance man and the maintenance department, to the plant engineer, there now emerges the "Lubrication Engineer," who, in this picture, it seems to me has special and important responsibilities. He has a two-fold job:

1. Research and analysis is required to develop fully all the facts in the problem of the use of machinery and equipment.

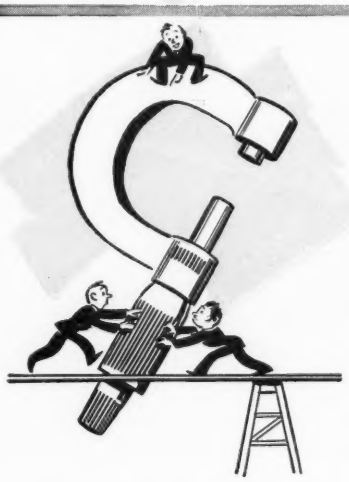
2. The presentation of the facts of the problem, and the conclusions with reference to the solution of the problem, to Management in such a manner that Management will listen, and will adopt the measures and the techniques required to arrive at the low costs necessary for profitable plant operation. You have a selling job, and only as you can operate more or less professionally, impartially and scientifically, can you gain the recognition that you deserve and get the results Management must have.

WHY IT PAYS TO USE THE *RIGHT* CUTTING OIL

LONGER TOOL LIFE



HIGHER PRODUCTION



CLOSER TOLERANCE

BETTER FINISH

BETTER CHIP SEPARATION

SHELL HAS THE *RIGHT* CUTTING OIL FOR EVERY APPLICATION

SHELL KNOWS THE IMPORTANCE of using the right oil for a particular cutting job. That is why Shell Lubrication Engineers balance the oil to fit the machine . . . the application . . . and the tool.

Make sure the machines in your plant get the benefit of all that's new in lubrication. Call the Shell Lubrication Engineer. Shell Oil Company, Incorporated, 50 West 50th Street, New York 20, New York; or 100 Bush Street, San Francisco 6, California.

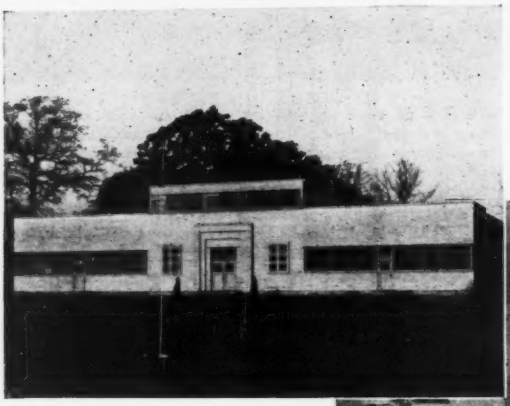
SHELL

SHELL CUTTING OILS

FOR METAL CUTTING AND GRINDING

NEW PRODUCTS and EQUIPMENT

ACHESON COLLOIDS PUTS NEW BUILDING IN OPERATION



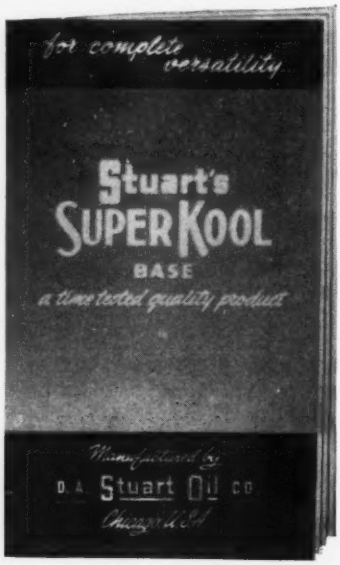
Photos Show Exterior of Building and Interior of Principal Laboratory.

New manufacturing and laboratory facilities, the latest additions in a long-range expansion program, have been placed in operation by the Acheson Colloids Corporation of Port Huron, Michigan.

Constructed by the Austin Company, the new units incorporate latest structural and design developments for production efficiency and employee comfort. The manufacturing section is comprised of two main production bays in which are employed the most modern methods of lighting, heating and ventilation. Particularly noteworthy are the two laboratory sections which are completely equipped for extensive research and product control.

Workers' facilities are highlighted by a modern lunchroom, private lockers, showers, and recreational areas. The structure itself is glazed tile with hammered glass windows, steel frame and interior supports, and its layout permits its ultimate linking with future buildings to form an integrated plant.

Acheson colloidal dispersions, sold under the trade-mark "dag," serve a wide variety of uses.



Announcement of New Booklet

For Complete Versatility . . . Stuart's SuperKool Base

Stuart's SuperKool Base Oil has earned wide acceptance for deep, heavy-duty drawing operations with stainless steel, beryllium, copper, and other difficult materials, and this and other applications of this sulphurized heavy-duty lubricant are outlined in a new eight-page booklet published by the D. A. Stuart Oil Company. This completely versatile base oil has also proved its value on a wide variety of different operations on many jobs including automatic screw machines, milling, broaching and gear cutting machines, when diluted with paraffin, light machine or other blending oils to fit the specific operation.

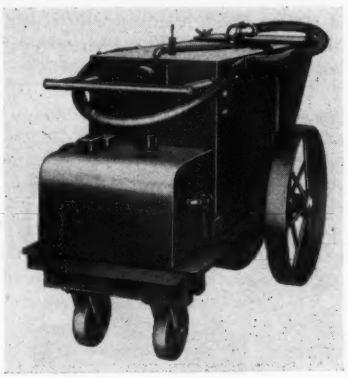
This informative booklet is available in a handy pocket-size edition which will be sent on request to men of the metal-working industries on writing D. A. Stuart Oil Company, Ltd., 2729-53 South Troy Street, Chicago 23, Illinois.

Improved Sump Cleaner Saves Time, Stops Waste

A redesigned and re-engineered Sump Cleaner is announced by Honan-Crane Corporation. This unit removes chips, grindings, cutting oil or soluble coolant from machine tool sumps; or scale and other contamination from quench and settling tanks, with greatest efficiency and maximum time saving. In actual operation the Sump Cleaner is said to clean up an individual machine in 10 minutes or less.

The Sump Cleaner transfers oil or coolant from sump to tank by vacuum and no contaminated liquids pass through the pump. Unit will transfer liquids from below floor level, maximum 20 feet, water.

A three-way valve instantly changes suction to pressure, permitting the unit to be used for dispensing clean liquids as well as removing dirty liquids. A hermetically sealed mercury contact switch, mounted on the Sump Cleaner and actuated by a float lever mechanism, automatically cuts out motor and pump units when the tank is filled. This eliminates waste of oil or coolant by spillage and insures cleanliness about the machine being serviced. Each unit is equipped with a drain valve for drawing off and liquid with salvage before dumping.



The Sump Cleaner is mounted on large wheels and the tank is balanced to permit quick, easy tilting for dumping of contents. Sump cleaning time is only a fraction of that required for hand cleaning.

Two sizes are available, with either 80 or 125 gallons capacity. Standard equipment includes a 1/2 hp. repulsion induction motor with V-belt drive, and starting switch; also a 10-foot heavy duty extension cord with plug and a 10-foot 1½" neoprene suction hose with 30" nozzle. Pump and motor units are fully enclosed in a sheet metal housing. Tank, frame and wheels are all steel and a heavy neoprene gasket seals the tank lid.

For more information write to Honan-Crane Corporation, 818 Wabash Avenue, Lebanon, Indiana.

New Bearing Design

Inventions of anti-friction bearings of the angle and radial types have been developed and patented by Vincent Palumbo, Chief engineer of the Pal-Vin Machine and Manufacturing Co., Cleveland, Ohio. The basis of these inventions is Palumbo's creation of a bearing in which the load is distributed substantially throughout the entire circumference of the bearing, rather than being borne only on the side, as in existing bearings.

Another important part of this invention is the increased load sustaining capacity afforded by multiplying the rows of rotating bearing elements built into the bearing. According to Palumbo, bearings incorporating these developments will have greater efficiency, last longer, these bearings are constructed so that the component parts can be made easily and inexpensively by prevailing methods.

These patents include not only bearings of multiple ball type, but also multiple pin, multiple roll, combination pin and roll, ball and roll and oil combinations involving balls, pins and rolls.

Franchises for this patented application of bearings are being offered to manufacturers.

Water Soluble Oils

A recent development that has been translated to commercial production now makes available in commercial quantities a number of chemical esters, of an oily character, that dissolve clearly in water.

Chemically these products are polyoxyethylene oleates and laurates having a molecular weight above 800. They are non-ionic, non-toxic, light in color and fluid or grease-like in consistency. They dissolve clearly in water, alcohol, esters, hydrocarbons and vegetable oils. At 20°C they are slightly heavier than water. They all have high boiling points and exhibit surface-active properties.

The above properties indicate their use as special detergents in textile and fiber processing; as penetrating lubricants; grinding media for pigments; plasticers for water dispersed products and water-insoluble resins, elastomers, plastics, coatings, etc.; emulsifying agents for oils and hydrocarbons.

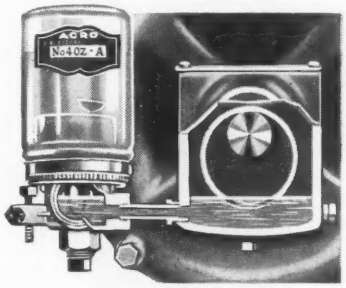
They are produced and sold under the names of Polyethylene Glycol Mono Oleates (S1005) and S1010) and Polyethylene Glycol Mono Laurate (S1019) by the Glyco Products Co., Inc., Brooklyn, N. Y., from whom samples and a specification sheet are available.

"Dual Visibility" Oiler Simplifies Problem of Proper Bearing Lubrication

An automatic lubricating device, scientifically designed after years of practical study in constant-level lubrication, has been developed by engineers of Acro Metal Stamping Co., 1919 North Buffum St., Milwaukee 12, Wisconsin.

Known as the Acro Lubricator, the unit simplifies the problem of motor bearing lubrication. It is a small, compact oiler that quickly attaches to electric motors, blowers, lineshafts, and similar mechanisms requiring a continuous supply of bearing oil. There are no floats, valves, or other moving parts in the lubricator, yet it always maintains the exact oil level necessary for correct lubrication. This simple, automatic, trouble-free feature practically eliminates machine failure due to faulty lubrication.

To set the oil level desired on the motor bearing, Acro engineers devised a simple finger set-screw for quick and easy adjustment from the outside of the lubricator. Once set, no further adjustment ever is necessary.



Fox River Tool Company Presents "Lubey"

Internal cleaning of machinery without disassembling by skilled mechanics is now possible through the newly patented Lubey Portable Oil Flusher manufactured by the Fox River Tool Company, Menasha, Wisconsin.

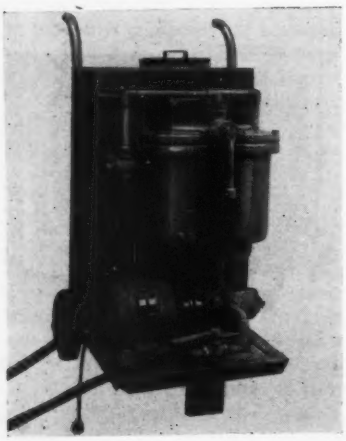
By means of a high pressure nozzle jet, organic solvents, kerosene or lubricating oil can be shot through the inspection or clean-out openings of housings around bearings, gears or cranks. Thus it is possible to loosen dirt, sludge or wear particles or force out water. Through a safety control device, the flow may be reduced to a gentle flushing stream if desired.

The residue may be drawn out through drain connections, or by suction hose, and collected in a filter. The flushing solvent is thus cleansed, and may be recirculated through the machine until the parts are clean.

The unit consists of a tank for holding and carrying the flushing fluid to and from the machine to be cleaned; a pump and driver for actuating the fluid; a filter for collecting the refuse cleaned out, and hoses, piping, valves and safety pressure control. It is so simple to operate that factory oilers can do the work formerly handled by mechanics.

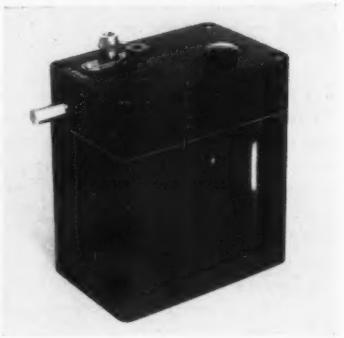
It is possible to use the unit as a simple lubricating oil circulating system. Heaters or coolers come with it as optional equipment, extra.

After a long period of field tests to prove its effectiveness, the Lubey Flusher is now in production for the market and makes its first public appearance in Booth #5 at the National Lubrication Exhibit sponsored by the American Society of Lubrication Engineers, and running con-currently with their Annual Convention, April 19th through 21st, 1948 at the Hotel Statler, Buffalo, New York.



Automatic Lubricator for Small Machines

Bijur Lubricating Corporation



Built Into Compact Assemblies, the Type "M" Lubricator Provides a Closely Controlled Oil Feed Down to a "Fraction" of a Drop for Each Bearing.

Designed for installation within small machines, the type "M" lubricator can effectively oil u pto 100 bearings with measured regularity. Automatically driven by the machine, this cyclic unit develops an average discharge pressure of 40 pounds per square inch, and discharges from 2.5 to 5.5 cubic centimeters (discharge volume is adjustable) at each pump impulse.

Used in conjunction with a meter-unit distribution system, the type "M" unit delivers small quantities of oil under accurate control to all bearings, gears and way surfaces of a machine at pre-determined intervals.

A completely automatic unit, this lubricator is driven from a rotating machine shaft, either directly or by means of a belt or gear drive of suitable ratio. Power requirements are negligible being of the order of .001 horsepower. The lubricator is available in several reduction ratios permitting the selection of the correct rates to accommodate the drive speed and the lubricator cycle time desired, and in both left-hand and right-hand drives.

Basically, the type "M" lubricator is a two-part mechanism, consisting of a lubricator unit mounted directly on a reservoir. The mechanical unit consists of a cover supporting the drive shaft, reduction gear mechanism and pump. The metering pump is of the piston type and is actuated by a cam driven through a series of gears. (Volume of the standard type "M" reservoir is 473 cubic centimeters (one pint).

Complete, Portable Handy-Shop For Repairs on Any Job

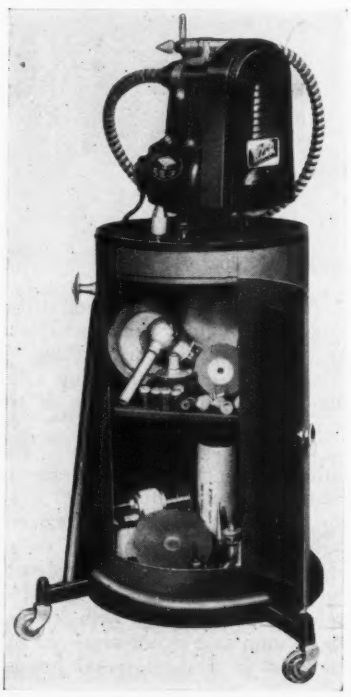
"The Handy-Matic," a motorized completely equipped portable repair shop for "on-the-spot" repairs anywhere, is announced by Wyzenbeek & Staff, Inc., 838 W. Hubbard Street, Chicago 22, Illinois.

It is an entirely new helper that will be hailed by all repairmen—an original type of flexible shaft machine mounted on a compact easily transported cabinet containing 25 accessory tools, and two dozen supplies that enable the repairman to go right ahead with the job wherever he finds it.

Power is supplied by a 1/3 h.p. motor, 110 or 220 volts, 60 cycle A.C. The flexible shaft is the WYCO, No. 10-P, five feet long, and has the famous WYCO non-metallic Inner-liner. Internally controlled flexing is built into the shaft housing to banish all heating, kinking or whipping. Three speeds are provided, 1400, 2400, 4500 r.p.m., with V-belt drive.

The cabinet, 32″ high, on three caster legs, is of strong all-steel construction with handsome gray crackle finish and glossy black trim. Is is conveniently equipped with shelves, enabling the repairman to find the desired tool instantly. Shipping weight 100 lbs.

Further information and low price of the completely equipped "Handy-Matic" may be had by addressing the manufacturer.



A Mobile, Lube Depot

The Industrial Division of Gray Company, Inc., of Minneapolis, manufacturers of lubricating and contracting, logging, mining, and other heavy equipment right "on location." It's ready at a moment's notice to lubricate bulldozers, cats,

maintenance equipment, is now marketing the Trail-Luber, a mobile lubrication depot for big machinery.

Complete, compact and self-powered, the new Trail-Luber services cranes, crushers, graders, scrapers, snow plows, and similar man-sized machinery. Here's a unit that specializes in on-the-spot lubrication, digs right in and gets the job done quickly, hustles "field work" along on schedule.

Included on the unit are: a two-compartment hopper for pressure lube and gear lube; two air-operated pumps; two 20-ft. lubricant hoses with suitable adapters; one 25-ft. air hose with airline coupler, tire chuck and blower valve; a Briggs & Stratton "A" Heavy Duty engine, rated 1¾ horsepower; and an air compressor with a 15-gallon storage tank, which delivers 7 CFM.

Two Trail-Luber models are available. One is skid-mounted, for easy mobility on pick-up truck, or for stationary mounting on dock or similar platform. The other, easily pulled behind car, truck or tractor, is mounted on automotive-type wheels with pneumatic tires, and has a tongue, tongue stand and trailer hitch.

For additional information about the Graco Trail-Luber, or other industrial lubricating or maintenance equipment, write Gray Company, Inc., Industrial Division, Graco Square, Minneapolis 13, Minn.

New "Fluidrive" Hydraulic Coupling Developed by Craneveyor Corp.

Cartridge-mounted shaft bearings are designed as an integral part of the new "Fluidrive" Hydraulic Coupling manufactured by the CraneVeyor Corp., 1240 So. Boyle Avenue, Los Angeles, California. An important design feature, the shaft-end bearings in the drive coupling itself, assure permanent shaft alignment, prevent shaft play, possible damage to Neoprene bellows seals and subsequent oil leakage. The extra large bearings easily carry the combined radial and thrust loads as well as positively align runner and impeller elements.

The new "Fluidrive" is a completely self-contained hydraulic coupling, with simple impeller element and runner unit, mounted on its own integrally-fitted ball bearings. Straight radial vanes make possible operation in either direction with equal efficiency. Low inertia of impeller and runner facilitates quick stops and reversing duty. The unit is statically and dynamically balanced, requires a minimum of mounting space and is as simple to install as a standard flexible coupling.

"Fluidrive" is available immediately in two sizes: 8.5", with capacity up to 5 HP, and 9.5", with capacity up to 7½ HP. The housing is made of precision-molded aluminum alloy castings, with all mating surfaces accurately machined. Circumferential oil seal, sealed ball bearings, large area fins and fan blades, heat-treated hold down machine screws are additional features. Case-mounted models, double shaft extension models and units with motor and spur gear reduction will be available shortly.

"Fluidrive" makes it possible to use an electric motor of the exact size to operate a given load at normal running speed: starts at virtually "no-load," gradually accelerates the driven machine to prescribed speed. Excessive starting current demands thus are eliminated. Overload relay protection can also be provided. By eliminating sudden shock loads, "Fluidrive" enables the carrying of greater torque loads on various chain drives, gearing and speed reducers.

Chicago Metal Hose Purchases Wheelock Mfg. Co.

Wheelock Manufacturing Company, St. Johnsbury, Vermont, has been purchased by Chicago Metal Hose Corporation and is being operated as the Wheelock Manufacturing Division.

The Wheelock Manufacturing Company has been in existence as a manufacturer for over one hundred years, having developed processes for the manufacture of coolant hose and flexible lamp arm tubing which they supply industry generally.

Chicago Metal Hose Corporation has not previously manufactured these items and with the addition of Wheelock Manufacturing Company's facilities, further adds to the already extensvie line of flexible metal hose tubing.

The trade name of "Stay-Put" for coolant hose and flexible lamp arm tubing which has identified the Wheelock Manufacturing Company's products for years is being retained by Chicago Metal Hose Corporation.

The Wheelock Manufacturing Division is being continued at St. Johnsbury, Vermont, with an assimilation of administrative and manufacturing personnel into Chicago Metal Hose Corporation.

NATIONAL LUBRICATION EXHIBIT

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HOTEL STATLER

17th FLOOR

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APRIL 19, 20, 21, 1948

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LUBRICANTS
CUTTING FLUIDS
COMPOUNDS
CHEMICALS
ADDITIVES
TESTING METHODS
HANDLING EQUIPMENT

NEW { DEVICES / METHODS / IDEAS } FOR APPLICATION

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SPONSORED BY

THE AMERICAN SOCIETY OF LUBRICATION ENGINEERS

NEWS OF THE SECTIONS

West Coast A.S.L.E. Sections Welcome Maag

Mr. Oscar L. Maag, National President of the A.S.L.E., was welcomed by a large delegation of members of the Los Angeles Section on his arrival March 2nd at that city.

That evening at the Ethyl Corporation auditorium, Mr. M. A. Wise of the General Petroleum Corporation, and Chairman of the local Section, introduced Mr. Maag as the speaker of the evening, his subject being "Lubricants for Various Anti-Friction Bearing Applications." He also told of the progress and accomplishments of the National Society.

Mr. Oscar L. Maag arrived in San Francisco on the Southern Pacific Company Lark at 9:00 A. M. on March 4th, and was greeted by Dr. Robert Larsen, our Western Regional Vice President. After Mr. Maag and Dr. Larsen checked in at the Palace Hotel, they spent the morning at the Shell Development Company's great laboratory in Emeryville — adjacent to Oakland, for those less familiar with the East Bay geography.

After lunch, Mr. Maag was taken over to the California Research Company's laboratories at Richmond where Mr. Kavanagh completed Oscar Maag's education on petroleum research matters that Bob Larsen had so impressively ininiated. Later in the afternoon, Mr. Maag and Mr. Kavanagh drove over to Treasure Island for Mr. Maag's talk at the Northern California Section of A.S.L.E.

As a measure of the interest in Mr. Maag's talk, it need only be mentioned that companies like General Electric Company had over 15 engineers present and Standard Oil Company and Shell Oil Company, many more. The question period was very active and would have gone on indefinitely had Mr. Isbell not the presence of mind, in deference to Oscar's long day, to call the meeting to a close at about 10:15 P. M. The meeting was a tremendous success.

New Officers installed at the Northern California Section meeting were: Chairman, Harvey G. Isbell; Vice Chairman, John Boyce; Secretary-Treasurer, A. S. Horwitz.

Next morning, Friday, March 5th, Mr. McLennan took Mr. Maag on a concentrated tour of high spots in the city by the Golden Gate. It was Oscar's first visit. The tour started from the Palace Hotel, went to Podesta and Baldocchi's, America's finest florists; then up Maiden Lane to Union Square and Magnin's brand new store, where Oscar took a quick look at the latest in post-war shops on the Coast. From here, the trip followed to the Embarcadero, Fisherman's Wharf, Telegraph Hill, Chinatown, Nob Hill, Blum's Candy Shop, Golden Gate Park, and the Beach. At this point, it was discovered that no time remained for a visit to the Redwoods in Muir Woods, so the next stop was the U. S. Navy Yard, Mare Island. Oscar then became the guest of the new Section Chairman, Mr. Isbell.

After lunch at the Officers' Club, Mr. Isbell showed Oscar through the Yard where he had a number of opportunities to discuss his favorite subject. Upon completion of the tour, our visitor was driven back to Oakland, where he leisurely caught his train for his next stop, Colorado Springs.

PITTSBURGH

The regular monthly meeting of the chapter was held at the Keystone Hotel, Friday evening, February 20th, fifty members and guests attending.

Mr. R. A. Baudry of Westinghouse Electric Corporation and Mr. C. A. Troutman of Gulf Research and Development Corp. headed an interesting discussion on General Lubrication, accompanied by charts and slides. The entire membership joined in a very active discussion period.

The subject of the meeting on March 19th was announced as "Lubricant Tests and their Significance" by Mr. Henry Muller of Shell Oil Company, New York.

The meeting will be held, as usual, at the Keystone Hotel.

INDIANAPOLIS

Koldermann Speaks at Sectional Meeting

An interesting evening was enjoyed by members and guests of the Indianapolis Section, when Mr. R. W. Koldermann of the Dow Corning Corporation gave a talk on "Silicones," the new industrial material —stressing its application in synthetic lubricants—pointing out the various characteristics and applications.

The 4th Monday in each month was designated as the regular meeting night. Mr. Donald Wilson of the Continental Steel Company at Kokomo was appointed Vice Chairman and Mr. J. E. Burns, Sr., was appointed representative of the Section at the National Convention in April.

BALTIMORE

On the evening of March 5th, a meeting of the Baltimore Section was held with an attendance of 50. The speaker of the evening was Mr. J. L. Palmer of the Lubri-Zol Corp., who spoke on the "Practical Aspects of the Use of Additives in Motor and Gear Oils in the Modern Automotive Engine."

After a considerable discussion period, which was accompanied by slides showing test procedure on Maryland roads, a unanimous vote was taken to hold a succession of similar meetings with round-table discussions.

After a report of the Nominating Committee, the following officers were unanimously elected:

Dr. Victor A. Ryan, Chairman;

Mr. Andrew E. Cichelli, Vice Chairman;

Mr. P. Raymond Staines, Secretary and Treasurer.

The next meeting is set for some time in the month of April. The exact date will be announced later.

The Officers and Directors of the A.S.L.E. extend their greetings and congratulations to the newest of the Sections.

(*Continued on page* 97)

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Membership in the Society is in several grades as defined below. Assignment to grade is made by the Admissions Committee or Board of Directors on the basis of information submitted or supplied by references.

MEMBERS
$10.00

Members shall be: (1) persons not less than twenty-four years in age who are engaged in research and instruction at technical schools, universities and various publicly and privately supported institutions in the field of lubrication; or (2) persons not less than twenty-four years in age who have occupied recognized positions as Lubrication Engineers for a period of three or more (not necessarily consecutive) years prior to date of admission, involving the responsibility for or supervision of the development, selection, field use and application of lubricants as differentiated from other activities; or (3) persons not less than twenty-four years in age who are indirectly concerned with the field of lubrication, but possessing other qualifications of experience, knowledge and accomplishment, have manifested a particular interest in the purposes and welfare of the Society, to the extent that their membership would be a valuable contribution to the successful functioning of its activities.

JUNIOR MEMBERS
$5.00

Junior Members shall be: persons less than twenty-four years in age, and those who do not completely fulfill the membership requirements for Members.

INDUSTRIAL MEMBERS

Industrial members are such persons or organizations as may be interested in and desire to contribute to supporting the purposes and activities of the Society. The fees paid by an industrial member in general will not be allowed to exceed $200.00 per year.

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*Denotes Residence Address Preferred.

NEWS OF THE SECTIONS

(*Continued from page* 95)

CHICAGO

At a joint meeting—A.S.T.E.-A.S.L.E.—Monday, March 1, 1948, the two Societies joined in an interesting session, when Mr. Arthur Mackmann, President of Amgears, Inc., and Mr. William H. Oldacre, President of the D. A. Stuart Oil Co., discussed the various phases of "Gear Manufacture and Lubrication." Mr. Mackmann and Mr. Oldacre are both competent leaders and authorities in their respective fields. When these men speak, they pack thirty years of practical experience behind every word.

Mr. Mackmann's subject of "Gears, Their Manufacture, Design and Practical Usage" was ably balanced by Mr. Oldacre's explanation of the necessity for proper and accurate choice of cutting fluids.

The 225 members of the two Societies attending the session joined in an enthusiastic discussion after the two speakers had finished.

An excellent dinner was served on the 17th floor of the Furniture Mart Building, and it is hoped by those in attendance that this will be an annual feature of both Societies.

NEW YORK

The January 22nd meeting of the Section was held at the Midston House with the subject of "Industrial Hydraulic Oil Additives," by Mr. J. Van Gundy of the Texas Company, following which Mr. E. L. Midgette of the Brooklyn Polytechnic Institute discussed the subject of "Design and Operating Characteristics of Hydraulic Pumps."

Mr. C. H. Parks of the Bullard Company presented a prepared discussion and showed a sound film illustrating "Hydraulic Circuits of Selective Spacers in Machine Tool Operation."

Mr. E. M. May, Eastern Representative of Bowser Company, Inc., was elected Chairman of the Membership Committee.

DETROIT

The monthly dinner meeting of the Section was held on February 23rd at the Horace H. Rackham Educational Memorial.

At the meeting which followed the dinner, Mr. E. D. Harkins of the Farval Corporation presided at a symposium devoted to "Centralized Lubrication Methods and Systems as an Aid to High Speed Production." Contributing speakers were Mr. Morgan Lawton, Mr. J. W. Fauver, Mr. Donald Price, Mr. Walter Marshall, and Mr. F. M. Hewitt. Much interest in the general discussion was evidenced. This was followed by moving pictures showing "Machining Crankcases—The Modern Way."

Future meeting dates were announced as follows:

March 22nd
April 26th
May 24th.

Sidelights on the Buffalo Convention and Exhibit, A. S. L. E.

As the date of the National Meeting approaches, the Officers and Directors of the Society and the Chairmen of the various Committees necessary to complete such an undertaking, feel that this year's meeting will set a precedent for future Conventions of the Society.

An innovation this year will be the National Lubrication Exhibit which will be held in conjunction with and on the same floor as the Convention meetings. A great deal of thought has been put into the selection of the Exhibits which will display everything from laboratory equipment, lubricants, cutting fluids and application devices, from the simplest oil and grease fittings to the more complex mechanisms of the automatic systems.

10,000 square feet of floor space has been allotted to the Exhibition hall and will present a most attractive arrangement of booths and individual designs for Exhibits. On another page in this issue, the complete list of exhibitors is given, together with the floor plan showing locations.

This is the first time in the history of Lubrication that manufacturers of equipment, lubricants and testing devices have been gathered together in one group to enable the members and guests attending the Convention to view the key products of the key manufacturers in the industry. Many of the Exhibits will show apparatus in actual operation.

Sessions in two meeting rooms, running simultaneously, have been arranged for Tuesday and Wednesday. These sessions offer a wide range of subjects and the speakers have been chosen for their authoritative position in the field they represent.

Judging from the reports of the Statler Hotel management as to the number of advance reservations already made, we shall have the largest attendance and registration of any of the annual meetings in the past.

SPECIAL LATE BULLETIN FROM L.A.

Announcing election of new Officers, as follows:

Chairman, M. A. Wise, General Petroleum Corp.

Vice President, Peter Kyropoulos, California Inst. of Technology.

Secretary-Treasurer, R. L. Engel, Allis-Chalmers Mfg. Co.

OILS AND LUBRICANTS PATENT ABSTRACTS

Printed copies of patents are available from the Patent Office at twenty-five cents each. Address the Commissioner of Patents, Washington, D. C., for copies and for general information concerning patents.

From Official Gazette—Vol. 606, Nos. 1, 2, 3, 4; Vol. 607, Nos. 1, 2, 3.

Prepared by ANN BURCHICK

Aqueous Dispersions of Vulcanized Fatty Oils—Patent #2,433,831—Laszlo Auer.

An oil-in-water dispersion the dispersed phase, of which incorporates a fatty oil haing a water soluble soap thoroughly dispersed therein, the cation of said water soluble soap being a member of the class consisting of alkali metals, ammonium and organic amines, said fatty oil being a heat bodied oil which is in a fully vulcanized state, and said water soluble soap is produced in situ during the preparation of the heat bodied oil, by water soluble compounds containing cations which form water soluble soaps with fatty acids.

Sulfurized Oils—Patent #2,433,853—Bert H. Lincoln and Waldo L. Steiner, assignors, by mesne assignments, to The Lubri-Zol Development Corp.

A lubricant comprising in combination a major proportion of an oil of lubricating viscosity and a minor proportion, sufficient to increase the film strength of the oil, of a halogen-bearing sulfurized ester of a phenol and an unsaturated organic acid, said ester being sulfurized with a phosphorus.

Grease Composition—Patent #2,433,861—George M. McNulty and John C. Zimmer, assignors to Std. Oil Development Co.

An anhydrous, high temperature reversible grease composition comprising a mineral lubricating oil and a soap consisting of the reaction product of a soap stock and a polyvalent metal hydrate heated to a temperature of 400° to 500°F.; and 0.1-5% of a chlorine-containing material selected from the group consisting of HCl and polyvalent metal halide, said chlorine containing material being incorporated as a substantially water insoluble integral part of said soap and being effective to raise the reaction temperature of formation of said soap substantially above the reaction temperature of similar soaps free of said chlorine containing material.

Selective Adsorption of Lubricants—Patent #2,434,113—Henry W. F. Lorenz.

A method of extracting oiliness agent from a lubricating oil containing an oiliness agent comprising: thoroughly wetting a solid metal having a melting point below 200°C. with a lubricating oil to impregnate and coat the surface of the metal with oil, separating unattached oil from the metal, melting the metal to set free the attached oiliness agent and recovering the oiliness agent by gravity separation.

Method of Producing Oil—Patent #2,434,239—John Z. Zublin.

A method for separating oil from sand, colloidal matter,, and the like while the oil is being produced from a vertical well, comprising drilling a downwardly and sidewardly deviating drain hole from a vertical well, filling at least the downwardly curved section of said drain hole with a gravel-like filter medium, flowing the oil through said laterally deviating drain hole and upwardly through the filter medium in the downwardly curved portion thereof to the mouth of said deviating drain hole and thence into the vertical well at a point above the bottom thereof, and separating by gravity and collecting at the bottom of the vertical well additional entrained materials before the oil is delivered to the surface at the top of the well.

Rust Preventive Lubricating Oil Compositions—Patent #2,434,490—Gordon W. Duncan, assignor to Standard Oil Development Co.

A slushing composition consisting essentially of a material selected from the class which consists of petroleum lubricating oils and petrolatum and 0.5 to 10% by weight of a fatty acid monoester of sorbitan, the fatty acid radical of said ester having between 8 and 30 carbon atoms, the quantity of said ester being sufficient to impart rust preventing properties to said petroleum composition.

Lubricants—Patent #2,434,539—Alan Beerbower and Arnold J. Morway, assignors to Standard Oil Development Co.

A continuous method for producing anhydrous greases which comprises first forming a slurry of dehydrated metal hydroxide in lubricating oil by heating a mixture of at least partially hydrated metal hydroxide and said oil to a temperature range of above 225°F., to substantially dehydrate said metal hydroxide, said hydrated metal hydroxide being selected from the group consisting of $LiOH.H_2O$, $Ba(OH)_2.8H_2O$ and $Sr(OH)_2.8H_2O$ next reacting said slurry with hot high molecular weight fatty acid at a temperature at which the soap formed by the reaction of said metal hydroxide with said fatty acid will remain dissolved in the oil, and finally cooling the reaction mass to form a grease.

Anticorrosion Additives for Synthetic Lubricants—Patent #2,434,978—William A. Zisman and Hayward R. Baker, assignors to the United States of America, as represented by the Secretary of the Navy.

A synthetic hydraulic and lubricating fluid composition which comprises essentially a polyakylene oxide fluid having dissolved therein a corrosion inhibitor, which inhibitor comprises at least one compound selected from the group consisting of aliphatic acids, alkaryl derivatives of aliphatic acids, and metal soaps of said acids, wherein the sliphatic acid is one having from about 6 to 18 carbon atoms in the aliphatic chain.

Method of Dispersing a Foam-Reducing Silicon-Containing Compond—Patent #2,435,124—Loren C. Bollinger, assignor to Shell Development Co.

A method of dispersing a foam-reducing silicon-containing compound in a hydrocarbon lubricating oil which comprises dissolving a compound having a formula selected from the group consisting of

$$\left(\begin{matrix} R \\ R \end{matrix} > Si = O\right)_n \text{ and } \left(\begin{matrix} RO \\ RO \end{matrix} > Si = O\right)_m$$

wherein each R is a saturated non-aromatic organic radical, and n and m are positive integers of at least 2, in an aliphatic hydrocarbon having a Saybolt Universal viscosity of less than about 50 seconds at 100°F., and then incorporating said hydrocarbon containing said foam-reducing compound into a hydrocarbon lubricating oil by agitation caused by passing a gas through said oil.

Nonfoaming Compositions—Patent #2,435,206—Garland H. B. Davis and John C. Zimmer, assignors to Std. Oil Development Co.

A composition of matters consisting essentially of a mineral lubricating oil containing metallo-organic addities which tend to cause excess foaming of said oil upon heating and/or working, and .0001 to 10% by weight of a substantially oil-insoluble anti-foaming agent selected from the highly fluorinated aliphatic hydrocarbons haing 5 to 50 carbon atoms and composed of 60 to 80% fluorine by weight, 20 to 37% carbon, and 0 to 3% hydrogen.

Preparation of Lubricating Oil—Patent #2,435,483—Richard S. Vose, assignor to Sun Oil Co.

The method of alkylating hydrocarbons which comprises reacting a hydrocarbon charge boiling above 400°F. containing a substantial proportion of naphthenic constituents and containing less than about 10% aromatics with at least a substantially equimolar quantity of an aliphatic alcohol containing at least 8 carbon atoms per molecule under alkylating conditions and in the presence of a catalyst of the water absorbing type.

Lubricant Compositions—Patent #2,435,619—David W. Young and William J. Sparks, assignors to Std. Oil Development Co.

A composition comprising a major proportion of mineral lubricating oil and a V.I. improving amount of a polyester condensation product of the reaction of a compound selected from the class consisting of dicarboxylic acids and lower aliphatic esters of dicarboxylic acids with a glycol, at least one of said monomeric substances having at least 10 carbon atoms per molecule, the said polyester being completely soluble in paraffinic oil having a viscosity index of at least 100, at temperature as low as 30°F., and being substantially free from polyester fractions less soluble in suen paraffinic oil.

Winterizing Oils—Patent #2,435,626—Chester M. Gooding and John R. Rich, assignors, by mesne assignments to The Best Foods, Inc.

A method for separating solid crystals from a glyceridic oil in which they are in solution, comprising adding to the glyceridic oil a crystallization modifying agent comprising lecithin which is soluble in the glyceridic oil and which reduces the solidification point of the glyceridic oil, chilling the glyceridic oil sufficiently to crystallize the solid crystals, and separating the glyceridic oil therefrom.

Lubricant—Patent #2,435,655—Herbert D. Rhodes, George F. Rouault, and Claron N. White, assignors to Standard Oil Company.

An oxidation stable and rust inhibiting hydrocarbon oil composition comprising a hydrocarbon oil normally susceptible to oxidation and lacking rust inhibiting properties and in combination therewith from about 0.001% to about 0.1% of a beta naphthol, from about 0.001% to about 3% of N-phenyl-alpha-naphthylamine, from about 0.0005% to about 0.5% stearic acid, and from about 0.0005% to about 1% naphthenohydroxamic acid.

Catalytic Isomerization of Unsaturated Glyceride Oils—Patent #2,435,695—Charles J. Plank, assignor to Socony-Vacuum Oil Company, Inc.

The process which comprises treating an oil selected from the class consisting of drying oils and semi-drying oils, at a temperature falling within the range varying between about 450°F. and about 600°F., with a boron trifluoride-bodied China-wood oil gel.

Method of and Apparatus for Treating Oil—Patent #2,435,707—Ulric B. Bray, and John K. Russell.

The method of facilitating the removal from a lubricating oil of the colloidal impurities produced therein durin the operation of an internal combustion engine, which comprises: adding a non-aqueous slightly oil-soluble aggiomerating amino soap to an oil so contaminated; and thereafter filtering out the agglomerated masses produced by such addition, said addition and removal being rendered continuous during the use of the oil by circulating the contaminated oil through a supply of said agglomerating agent and a medium capable of producing such filtration.

Method of and Apparatus for Filtering Oil—Patent #2,435,734—Ulric B. Bray and John K. Russell.

The method of treating a flowing stream of substantially non-acidic lubricating oil during contamination by suspended impurities of a particle size insufficient for filtration, which includes the steps of: agglomerating such impurities along the oil stream at substantially the rate at which they are suspended in the oil to bodies of dimensions sufficient for removal by filtration with an agglomerating amino soap of castor oil fatty acids and having slight solubility in the oil; separating said agglomerated bodies from the lubricating oil at substantially the rate at which such bodies are formed by passing the oil containing such bodies through a filter interposed in the stream; and maintaining the quantity of the agglomerating soap in solution in the oil substantially constant by replenishing the soap in solution in the oil at the rate it is removed therefrom by the agglomeration of such suspended impurities.

Emulsifiable Soluble Oil Compositions—Patent #2,436,046—Norman E. Lemmon and Frederick W. Schuessler, assignors to Standard Oil Company.

A readily normally liquid soluble oil composition comprising a major proportion of a hydrocarbon oil, from about 5% to about 11% of a sodium soap of a preferentially oil soluble petroleum sulfonic acid having a molecular weight above about 450, which soap is normally unsuitable for use in soluble oil compositions, from about 0.5% to about 10% of a water soluble alkylated aromatic hydrocarbon sulfonate in which the alkyl substituents contain from about 9 to about 17 carbon atoms, in the side chain and from about 1% to about 3% water.

Lubricant—Patent #2,436,051—Lawson W. Mixon, assignor to Standard Oil Company.

A normally liquid lubricant composition comprsing a major proportion of a hydrocarbon oil and from about 0.05% to about 10% of a zinc organo trithiocarbonate of the group consisting of a zinc alkyl trithiocarbonate and a zinc alicyclic trithiocarbonate.

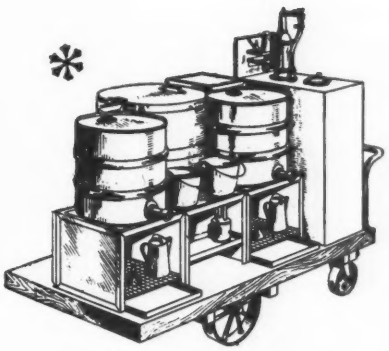
Oils and Greases Obtained by Pyrolysis of Tetrafluoroethylene Olefin Copolymers—Patent #2,436,069—Robert M. Joyce, Jr., assignor to E. I. duPont deNemours and Co.

A composition of matter which in physical properties ranges from an oil to a grease, which has a percentage unsaturation of at least 25, and which is obtained by heating in an inert atmosphere at a temperature of from 400°C. to 700°C. a normally solid copolymer of tetrafluoroethylene and a mono-olefinic hydrocarbon having from 2 to 4 carbon atoms until the copolymer is converted to a product which has said physical properties and percentage unsaturation, said copolymer containing from 10 to 60 mol per cent of tetrafluoroethylene.

Mineral Oil Composition—Patent #2,436,272—George H. S. Snyder, Ralph V. White, John H. Bishop, and John F. Socolofsky, assignors to Socony-Vacuum Oil Co., Inc.

A mineral oil composition comprising a viscous mineral oil having in admixture therewith a minor proportion, sufficient to impart anti-rusting characteristics to said oil, on an ester product of malic acid selected from the group consisting of: an ester product of malic acid obtained by reacting one molar equivalent of malic acid with from about 0.8 to about 1.6 molar equivalents of a short-chain aliphatic alcohol having from 6 to 8 carbon atoms and with from about 1.2 to about 0.4 molar equivalent of a long-chain aliphatic alcohol having between 12 and about 18 carbon atoms; and a mixture of esters of malic acid, one of said esters having two short-chain aliphatic groups containing from 6 to 8 carbon atoms substituted for the carboxylic hydrogen atoms of malic acid and said ester being present in the mixture in a molar quantity of from about 40 to about 80%, and another of said esters having two long-chain aliphatic groups containing between 12 and about 18 carbon atoms substituted for the carboxylic hydrogen atoms of malic acid and said ester being present in the mixture in a molar quantity of from about 60 to about 20%.

lubrication is more than just the lubricant*...



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In the preparation of preservative lubricants for the shipment of engines and replacement parts.

In the preparation of automotive, diesel and industrial oils of enhanced lubricity and detergency.

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Write directly attention RESEARCH DIRECTOR

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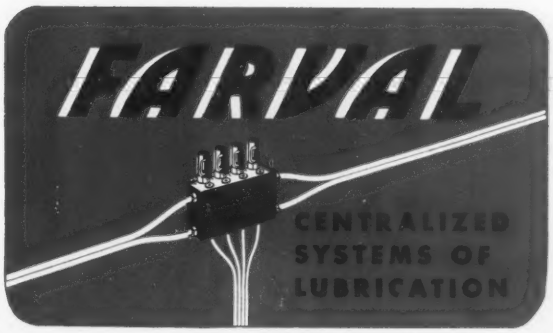

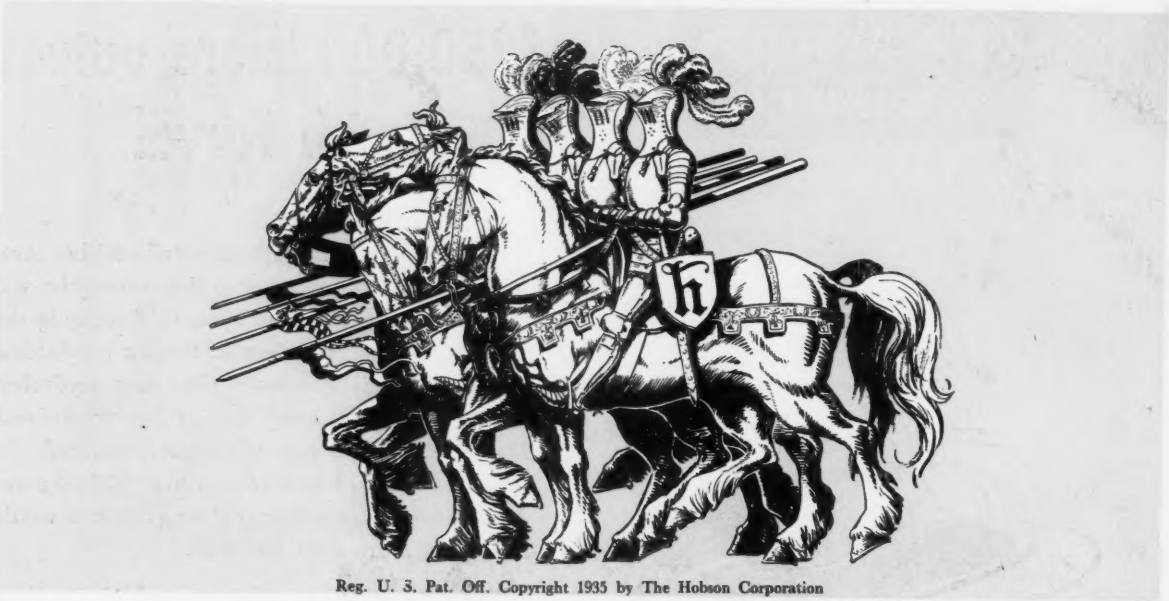

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